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Psychological Monographs

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MADISON BENTLEY, UNIVERSITY OF ILLINOIS (*Index*)

A Tentative Standardization of a Hard Opposites Test

BY

MARIE HACKL MEANS, PH.D.

PSYCHOLOGICAL REVIEW COMPANY
PRINCETON, N. J.
AND LANCASTER, PA.
AGENTS: G. E. STECHERT & CO., LONDON (2 Star Yard, Carey St., W. C.)
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Grateful acknowledgment is due Dr. Edward K. Strong who suggested the problem and Dr. Joseph Peterson under whose guidance and help the work was completed. The writer also wishes to thank those students of Peabody College who acted as subjects, as well as the following men and women who so kindly gave of their time to make the completion of this research possible: Dr. Harvey Carr, Miss Cora Bratton, Dr. George Arps, Miss Mary Small, Dr. Walter Hunter, Dr. Florence Richardson, Dr. Benjamin Simpson, Dr. Norman Triplett, Dr. Franklin Smith, Dr. Homer Bean, Dr. E. A. Gamble, Mr. E. A. Kirkpatrick, Dr. C. A. Ruckmick, Dr. M. R. Trabue, Dr. George W. Camp, Dr. W. B. Pillsbury.

It would be most ungrateful for the writer not to acknowledge the help and encouragement received from her mother.

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A TENTATIVE STANDARDIZATION OF A HARD OPPOSITES TEST

I.

The Problem and its Importance

There have been many attempts to apply mental tests to college students, but the results have not been on the whole satisfactory. The very homogeneity of the college group, brought about by the natural process of the elimination of the unfit, should have warned us not to expect results comparable to those obtained from children and unselected adults. The minute individual differences of degrees of accuracy or rate of performance can be detected only by the use of a most delicate scale.

Therefore to raise our correlations of mental tests and estimated intelligence it is necessary that greater attention should be paid to the selection of the tests themselves. Where the higher functions are involved it is better to avoid tests of co-ordination and sense discrimination as well as those tests, success in which is largely dependent upon speed of performance rather than accuracy. Unfortunately the humbler task of standardization for convenient use has been neglected and until investigators have at their disposal a number of such tests, our attitude toward the validity of mental testing of college students should be highly tentative.

This present investigation was attempted in the hope of contributing a small amount toward the preparation of some adequately standardized tests. To evolve out of a test in common use a vastly more difficult test, to determine the relative difficulty of its parts, to standardize the responses which are acceptable, and to set up workable norms with which comparisons could be made—this specifically was our aim. For this purpose we have chosen an opposites test. No effort has been made to obtain correlations with other tests and no claim is made that the test, as it now stands, has mentally diagnostic values of high importance for the individual.

II.

THE RESULTS OBTAINED BY PREVIOUS INVESTIGATORS

The diversified use of the opposites test, with its different methods of presenting and scoring, has yielded results which, while not altogether comparable, are not without interest.

Dr. Bonser[1] in an investigation of the reasoning ability of children in the upper division of the fourth, fifth, and sixth grades of the public schools of Passaic, New Jersey, tested three hundred and eighty-five boys and three hundred and seventy-two girls within the period of February 13 to 27, 1906. The tests employed were designed to exercise the most fundamental phases of reasoning ability, namely, mathematical judgment, controlled association, selective judgment, and the analytic and synthetic thinking necessary for the intellectual interpretation of literature.

For controlled association, three types of tests were used. First, in two sets of ten sentences presented, a significant word was omitted from each sentence, which was to be filled in by the pupils. Second, two other sets of ten sentences were given, in each of which two significant words were placed one above the other. The pupils were instructed to draw a line through the wrong word, leaving the sentence so it would read correctly. Third, three sets of twenty words each were given to the pupils with the instructions that they were to write beside each respective word a word just its opposite in meaning.

For selective judgment two types of tests were used. The first consisted of two sets of two series each of ten reasons why some given fact is true, some of which are correct, the others incorrect. The pupils were to check the former. Second, there were given two sets of three series each, of five definitions of a given thing or term, some of which were correct, others incorrect or irrelevant. The pupils were to choose the right definition. In the table below these tests are indicated as V and VI respectively.

---

[1] Bonser, Frederick G., "The Reasoning Ability of Children of the Fourth, Fifth, and Sixth School Grades," *Col. Univ. Cont. Ed.*, 37, 1906, 1-101.

For literary interpretation the pupils were asked to write the meaning of two stanzas of poetry.

Below is shown the coefficients of correlation obtained by correlating each test with the combined score of all the tests.

TABLE 1

Bonser's Correlations of Each Test with the Totals for All Tests in Reasoning Ability.

Opposites and Combined Score	.85
Selective Judgment and Combined Score (V)	.73
Mathematical Judgment and Combined Score	.59
Selective Judgment and Combined Score (VI)	.58
Controlled Association and Combined Score	.55
Interpreting Poems and Combined Score	.37
Spelling and Combined Score	.22

Dr. Bonser has arranged for comparison separate tables for the younger and the older group in each grade. He finds the younger group superior in the opposites test for every grade, but this superiority diminishes as the years in school increase. This would indicate, he thinks, that the test is one which reveals some sort of native ability, which is concealed in the upper grades where the test is relatively simple.

Miss Norsworthy[2] in a study of the comparison of defective and normal children found that the defectives were farthest removed from normal children in ability to deal with abstract data. Of the 137 cases ranging in age from eight years up, none of the defectives surpassed the median score for normal children in the opposites tests. This is shown in the following table.

Woolley and Fischer[3] in their work in connection with the industrially employed children in Cincinnati obtained results by the use of opposites tests which are highly significant. Over eight hundred children fourteen years of age were given the following

---

[2] Norsworthy, Naomi, "The Psychology of Mentally Deficient Children," New York, Columbia University, 1906.

[3] Woolley, Helen Thompson, and Fischer, Charlotte Rust, "Mental and Physical Measurements of Working Children," *Psychol. Monog.*, 1914, XVIII, 77, 213-241.

TABLE II

Norsworthy's Percentages of Children Scoring above —2 P. E., —1 P. E., and Median for Normal Children in Series of Tests.

	% above Med. for ordinary children	% above—1 P. E. (or lowest 25% of ordinary children)	% above —2 P. E. (or lowest 9% of ordinary children)
Height	45	61	77
Weight	44	66	77
Pulse	49	69	86
Temperature	26	59	77
Weight Test	18	28	39
A-T Test	1	14	28
Memory of Unrelated Words	6	18	27
Dictation	10	10	21
Memory of Unrelated Words	5	19	30
Part-Whole Test	9	17	27
Genus-Species Test	9	16	17
First Opposite Test	0	0.9	5
Second Opposite Test	0	1	7

physical and mental tests upon their entrance into the industrial world: Height, Weight, Visual Acuity, Auditory Acuity, Vital Capacity, Strength of Hand, Steadiness of Hand, Tapping, Card Sorting, Cancellation Test, Memory (Digits), Substitution, Completion of Sentences, Association by Opposites, and Puzzle Box Test.

A year later six hundred and seventy-nine of these boys and girls were re-tested.

In giving the opposites test one of the eight lists of twenty words printed one under another was presented to the subject who was requested to write beside each word another word opposite in meaning. The time was recorded for the total list but the scores were based on the percentage of accuracy alone. Credits of one, one-half, or zero were assigned to the responses given. Misspelled words were given full credit but adjectives written in place of adverbs received only half credit.

A positive correlation was obtained between the school grade completed at fourteen years of age and the ranking in every one of the mental tests. The general order is as follows: Memory, Association by Opposites, Sentence Test, Substitution Test, Cancellation, and Puzzle Box.

The public school children were found to be superior to the parochial school group, and their superiority was most decided in opposites and in the puzzle box tests, the two tests which, according to the investigators, are farthest removed from a relationship with school drill.

"There is a marked and consistent positive correlation with school grade in this test (opposites) for both sexes and at both ages. The differences from grade to grade are so large and so consistent that their significance cannot be questioned."[4]

While director of the Department of Psychology at the New York State Reformatory for Women, at Bedford Hills, Dr. Weidensall[5] began a series of experiments upon the women detained in that institution. It was hoped that a number of tests might be found which would prove prophetic of the convicted woman's reformability and would thus eliminate such cases which, because of inability to learn, consumed a disproportionate amount of time.

The major portion of the monograph deals with the records of the criminal woman as compared with the norms of normal working girls fourteen and fifteen years of age. The norms were being formulated at the time by Dr. Woolley[6] in her work as director of the Bureau of Vocational Guidance, Cincinnati, Ohio. Since comparisons were to be made, the tests which were being used by Dr. Woolley were adopted by Dr. Weidensall and given in approximately the same manner.

The women tested were admitted between the first of January and the end of October, 1913. Two hundred and eight were committed to Bedford during that period, but of that number only a hundred were tested. Because of lack of facility in the English language of twelve foreigners, the percentile tables and curves are based on eighty-eight records. All tests were given individually and during the first two weeks of confinement while the subject was still in quarantine.

---

[4] Woolley, Helen Thompson, and Fischer, Charlotte Rust, *Op. cit.*, 222.

[5] Weidensall, Jean, "The Mentality of the Criminal Woman," Baltimore, Warwick & York, 1916, 3-266.

[6] Woolley, Helen Thompson, and Fischer, Charlotte Rust, *Op. cit.*

The method followed in connection with the opposites test was to present a list of twenty words and to record the total time required for the subject to write the opposites. Results were based on the percent of accuracy, as it was found that the correlation between rank in time and accuracy in this test was as high as .83, P. E. .029.

All identical accuracy scores were arranged in point of time of performance and the rankings correlated with the native ability of the group as estimated by the director of the Industrial School of the Reformatory after she had worked with these women for from eighteen months to two years. This correlation was + .79, P. E. .026, and was obtained by the formula

$$r = 1 - \frac{6 \Sigma d^2}{n(n^2 - 1)}$$

This correlation, which was higher than that for any other test, would probably have been even higher had it not been necessary for the director to base her judgment of ten of the women on the reports of matrons. It was the difference in rank accorded these ten which was responsible for some of the largest variations from the rank of the test.

It is interesting to note that of the Bedford eighty-eight but thirty-nine percent attain or surpass the median record of the working girl of fifteen. Dr. Weidensall feels that the easy opposites test proved the most reliable of all tests given, for clinical purposes.

In 1912 Dr. Benjamin R. Simpson[7] selected two groups as widely different in intellectual status as possible, the one represented by seventeen professors and advanced students in Columbia University, the other by inmates of charitable institutions, with the exception of two who were recognized by their associates as being dull. The fifteen tests, which were given, were administered individually and in the same order.

The hard opposites test not only separated the two groups completely but correlated with the general intelligence of the good group, as estimated by the members which composed it, more highly than any of the other tests. The individuals of the good group were rated in order of merit for general intelligence, each by the rest of the group, four years after the tests were given. Two rankings made by the experimenter a month apart were included. The judgments, correlated with the various tests, are as follows:

---

[7] Simpson, Benjamin R., "Correlations of Mental Abilities," *Col. Univ. Cont. Ed.*, 1912, No. 53.

TABLE III

Simpson's Correlations of the Estimated Intelligence of his Superior Group with the Results of Eleven Tests

Estimated	Intelligence	and	Hard Opposites	.96
"	"	"	Ebbinghaus Completion Test	.89
"	"	"	Memory for Words	.93
"	"	"	Memory of Passages	.35
"	"	"	Easy Opposites	.82
"	"	"	Adding	.72
"	"	"	Learning Pairs	.34
"	"	"	Completing Words	1.00*
"	"	"	"A" Test	.21
"	"	"	Geometrical Forms	.07
"	"	"	Drawing Lengths	—.20

*This coefficient, according to Dr. Simpson, is not to be considered reliable, since the reliability coefficients of the Completing Words test in the Good group is only .27.

On account of the high correlation between the hard opposites and the Ebbinghaus Completion Test, Dr. Simpson feels that they test the same mental function, namely selective thinking.

Bronner[8] has endeavored to determine the intellectual status of the delinquent girl as compared with the intelligence of several other groups engaged in occupations and pursuits which, of necessity, required varied degrees of education and ability. Thirty girls living at Waverly House, a detention home maintained by the New York Probation Association, composed the delinquent group. The college group contained thirty-six girls, all members of the freshmen and sophomore classes of Barnard and

---

[8] Bronner, Augusta F., "A Comparative Study of the Intelligence of Delinquent Girls," *Col. Univ. Cont. Educ.*, 1914, No. 68.

Teachers' College. Thirty-four Jewish girls, who spent their evenings at the University Settlement or the Harlem Branch of the Y. W. C. A., engaging in educational pursuits, formed the evening class group. The fourth group was composed of twenty-nine girls who had never engaged in any wage-earning occupation except domestic service. None of these girls was pursuing studies whereby she hoped to prepare herself for a different occupation nor had she been guilty of offenses which had brought her in conflict with the law.

In addition to an ethical discrimination test, those tests employed comprise the Easy Opposites, the Hard Opposites, the Memory of Words, the Memory of Passages, and the Ebbinghaus Completion test. These tests were the same as those used by Dr. Benjamin Simpson in his study of *Correlations of Mental Abilities.* In the following table, which is a reorganization of five tables presented by Bronner, D represents the delinquent group, C the college group, E the evening class group, and S the domestic service group. These data show, as Bronner states, that the

TABLE IV

Comparisons of the Four Groups

Easy Opposites	
% of D reaching the 25 percentile of the C group	3.3%
% of E reaching the 25 percentile of the C group	15.0%
% of S reaching the 25 percentile of the C group	7.0%
Hard Opposites	
% of D reaching the 25 percentile of the C group	0.0%
% of E reaching the 25 percentile of the C group	12.0%
% of S reaching the 25 percentile of the C group	0.0%
Memory of Unrelated Words	
% of D reaching the 25 percentile of the C group	20.0%
% of E reaching the 25 percentile of the C group	59.0%
% of S reaching the 25 percentile of the C group	7.0%
Memory of Passages	
% of D reaching the 25 percentile of the C group	10.0%
% of E reaching the 25 percentile of the C group	15.0%
% of S reaching the 25 percentile of the C group	3.0%
Ebbinghaus Completion Test	
% of D reaching the 25 percentile of the C group	6.6%
% of E reaching the 25 percentile of the C group	9.0%
% of S reaching the 25 percentile of the C group	3.0%

college girls excel in all the tests. The delinquent girl is quite as capable as the domestic service girl, while both are surpassed by the girls attending evening classes.

The superiority of the evening class girls over the other two groups displayed in each test, cannot be attributed to more favorable educational advantages for none of the members had attended high school, whereas of the delinquent group, four had reached the eighth grade, two the first year of high school, two the second year, one was graduated, and one had attended a normal school.

The Hard Opposites Test separated the college group from the others almost entirely. Next in order comes the Ebbinghaus Completion Test, with the Easy Opposites ranking third. It is not without interest that Dr. Simpson found the Hard Opposites separated his good group entirely from his poor group and the Easy Opposites in this respect surpassed the Ebbinghaus Test.

Let us now examine the record of the Opposites Test when applied to the highly selected group, represented by the college student. In 1914 Dr. Kitson[9] began a series of tests upon the freshmen in the College of Commerce and Administration of the University of Chicago. One of the sixteen tests used was an opposites test. Two lists of twenty words each were presented and the time recorded for the subject to call the opposites of each list. Five points were deducted for each wrong word or for failure to respond within fifteen seconds, from the one hundred points allowed each list. The final score for the individual was obtained by dividing the time score by the accuracy score.

The stimuli were of such little difficulty that they measured for the most part merely speed of association. Almost half of the subjects obtained an accuracy score of one hundred in each list. Of forty students, thirty-one scored one hundred in accuracy in the easy list, and twenty-one scored a hundred in the hard list.

In his results Kitson has included the following table of correlations.

Of the fifteen tests used by Kitson, by computing the multiple and the partial correlations and the regression coefficients,

---

[9] Kitson, H. D., "The Scientific Study of College Students," *Psychol. Monog.*, 1917, 23.

TABLE V

Correlations of Standings in Each Test with Standings in the Net Score
(Method of Rank Differences)

	Correlations	P. E.
Logical Material Seen (Deferred)	.60	.07
Opposites	.53	.08
Hard Directions (Printed)	.49	.08
Objects Seen	.48	.08
Loss in Logical Material Seen	.47	.09
Logical Material Heard (Deferred)	.45	.09
Word Building	.45	.09
Loss in Logical Material Heard	.43	.09
Sentence Building	.42	.09
Constant Increment	.38	.10
Business Ingenuity	.33	.10
Logical Material Seen (Immediate)	.29	.10
Numbers Heard	.27	.10
Hard Directions (Oral)	.23	.11
Logical Material Heard (Immediate)	.23	.11
Number Checking	.18	.11

Rosenow[10] concludes that five of the tests carry all the meaning with reference to school marks and hence all diagnostic value. In the table below the writer has rearranged the results of Rosenow's investigation. From it one learns that the probability is 1300 : 1 that the Logical Memory is significant.

TABLE VI

Rearrangement of the Results of Rosenow's Investigation

Probability is 1300 : 1 that the Logical Memory Test is Significant.
" " 25 : 1 that the Constant Increment Test is Significant.
" " 30 : 1 that the Sentence Building Test is Significant.
" " 23 : 1 that Auditory Presentation is Superior to Visual.
" " 140 : 1 that the Loss or Gain in Logical Auditory Memory is significant.
" " that the Hard Directions Test has Negative Significance.
" " that the Objects Seen Test has Negative Significance.

The remaining tests, including the Opposites, have no diagnostic value.

In view of the fact that the stimuli used in the Opposites Test were the Woodworth and Wells standardized list, Rosenow's conclusions are not surprising. The words were of so little difficulty that they tested only speed of association.

---

[10] Rosenow, Curt, "The Analysis of Mental Functions," *Psychol. Monog.*, 1917, 24.

King and M'Crory[11] in testing two hundred and seventy-six women and two hundred and sixty-eight men in the freshmen class at the University of Iowa, applied seven tests, including both easy and hard opposites. The following table indicates the correlations which were obtained between the Opposites and other tests as well as university grades. The Opposites Test, they find, correlates most highly of any of the tests with the university marks of both men and women.

TABLE VII

Correlations of Opposites with Other Tests and University Grades

	Correlations	
	Women	Men
Opposites and Completion	.31	.79
" " Arithmetic (Speed)	.03	Neg.
" " Arithmetic (Accuracy)	.01	Neg.
" " Analogies	.52	.77
" " Information	.24	.56
" " Visual Imagery	.07	.56
" " Logical Memory	.32	.38
" " Test Average	.51	.88
" " University Grades	.45	.84

Dr. King[12] is of the opinion that the Opposites Test, if thoroughly standardized and used in conjunction with other tests, will yield results of great importance.

In the Spring of 1916, while the writer was yet engaged in the selection of appropriate stimuli for the present investigation, an opportunity[13] presented itself of correlating the grades of seventy-three students in psychology with the results secured by the use of the Opposites Test. An effort had been made to keep the two lists composed of one hundred and fifty words each, as nearly equal as possible. The two lists are given below. The words are arranged in random order. Those words which had not been used by previous investigators are in italics.

---

[11] King, Irving, and M'Crory, J. L., "Freshmen Tests at the State University of Iowa," *Jour. Educ. Psychol.*, 1918, IX, 32-46.

[12] King, Irving, and Gold, Hugo, "A Tentative Standardization of Certain Opposites Tests," *Jour. Educ. Psychol.*, 1916, VII, 459-482.

[13] Dr. Edward K. Strong, at that time Professor of Psychology at George Peabody College for Teachers, kindly furnished these data. The grades were compiled from the records of fourteen tests given during the quarter.

List I.—Defective, Late, Sinful, Easy, Hilly, Superior, Girl, White, Cool, Large, Evil, Queen, Deep, True, Public, Sink, Future, Adroit, Dangerous, Day, Ugly, Quick, Poor, Diligent, Wicked, Round, Ceiling, Broken, Gentle, Vague, Brief, Animated, Slovenly, Dim, Out, Rude, Lazy, Injurious, Conservative, Wet, Asleep, Stingy, Fertile, Wise, Calm, Tardy, Hinder, Respect, Big, Gain, Great, Profit, Young, Few, Summer, Above, Glad, Masculine, Remember, Off, Beginning, Love, Straight, War, Joy, Naked, Pride, Apart, Brave, Noisy, Fickle, Create, Wild, Despondent, Frequently, Timid, Hollow, Belief, Bad, Up, Sick, Empty, Strong, Inside, Front, After, Broad, Sharp, Sweet, Succeed, Add, Happy, Raise, Aristocratic, East, Short, Thick, Result, Rare, Stale, North, Hostile, Laugh, Obnoxious, Expensive, Near, Join, Hot, Forcible, Preserve, Strict, Handsome, Friend, Miser, Exciting, Rough, Brother, Light, Careful, Push, Haughty, Impoverish, Busy, Much, Graceful, Ocean, Precise, Barbarous, Ignorant, Reckless, Odd, Victorious, Repulsion, Permit, *Positive, Pessimistic, Extravagant, Durable, Analytical, Parsimony, Orthodoxy, Acute, Exoteric, Antonym, Dorsal, Longitude, Divide, Infinity, Dynamic, Posterior.*

List II.—Gay, Foolish, Drop, Giving, Cloudy, Blunt, Beautiful, Backwards, Well, Top, Success, Soft, New, Refined, Weary, Spend, Break, Male, Country, Dark, Weak, Black, Disastrous, Rigid, Elation, Hindrance, Savage, Degrade, Ripe, Shaky, Separate, Liquid, Sell, Honest, Difficult, Dirty, Wrong, Winter, Helpless, Obscure, Expand, Insignificant, Sleepy, Sad, Little, Enemy, Open, Yours, Yes, Conservative, Soothing, Doubtful, Sacred, Sure, Reveal, Stupid, Motion, Sickly, Slowness, Outside, Same, Cowardly, Float, Foreign, Strength, Sane, Level, Simple, Many, Lost, Something, Sour, Enrage, Serious, Long, In, Take, Tight, Prompt, Patient, Permanent, Genuine, Morning, Smooth, Heavy, Full, Grand, Humility, Tall, Over, First, Strife, Follower, Hold, Proficient, Vertical, Shallow, Absent, Rapid, Rich, Purity, Loquacious, Imaginary, Silly, Increase, Wider, Nowhere, Upper, Woman, Generous, Careless, Scarce, Height, Always, Wife, Best, Below, Thin, High, Early, Suave, Lack, Advance, Harmonious, Bless, Both, Cruel, Cheap, Ancient, Less, Forget, Come, Slow, Good, *Negative, Optimistic, Economical, Perishable, Synthetical, Prodigality, Heterodoxy, Chronic, Esoteric, Synonym, Ventral, Latitude, Multiply, Zero, Static, Anterior.*

The test was given individually and orally. The experimenter read the stimulus and recorded the response of the subjects as well as his reaction time. The accuracy score in percentage and the time score arrived at by computing the median time of all reactions were tabulated for each student.

In grading these papers, credits of one, one-half, or zero were assigned to the responses. What credit a word deserved was determined solely by the writer, as she was not yet ready to standardize the responses for so bulky a list.

In order to allow equal credit for time and accuracy the following formula was used:

$$\text{Individual score} = \frac{\dfrac{\text{Dt}}{\text{QT}} + \dfrac{\text{Da}}{\text{QA}}}{2} \quad \text{in which}$$

Da = the deviation of the individual accuracy scores from the accuracy scores of the group.

Dt = the deviation of the individual time score from the time score of the group. Since signs were regarded, where an individual had a lower time score than the group his deviation was positive.

QA = the quartile of the accuracy scores of the group.

QT = the quartile of the time scores of the group.

The coefficient of correlation obtained by the method of rank differences was .54, P. E. = .08. Speed and accuracy were likewise correlated, giving a coefficient of .33, P. E. = .10. This coefficient would hardly justify the statement that, in so far as this particular test is concerned, either accuracy or speed could be disregaded without affecting the rankings in the test.

In Figure I is shown the relative positions of the several members of the class in psychology and in the Opposites Test. The vertical line indicates the rank in the test, the horizontal line, the rank in psychology. A glance at the figure will show that on the whole those good in the test were good in psychology. The greatest exception is to be found in the position of the student indicated by the figure 5 in the graph. This woman of splendid ability was permitted by her physician to remain in school only on the condition that she would do the least possible amount of work to secure credit for the course in which she was enrolled. Case 4, a widow, had been out of school and school work for a number of years. The increased cost of living had forced her to return. Case 3 had registered in psychology because it was one of the required courses.

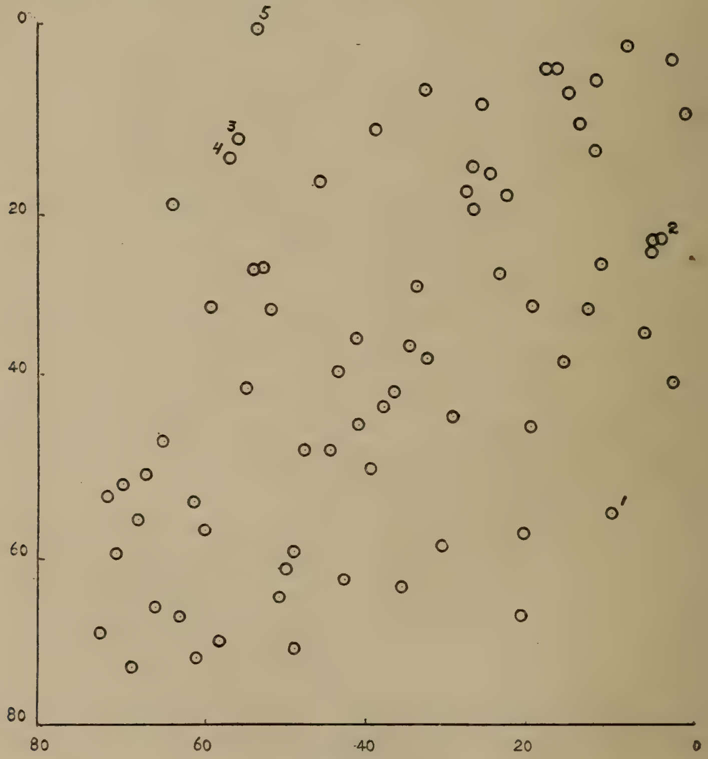

Figure 1

The relations between rank based on psychology grades and rank based on the Opposites Test score are shown here. Each circle indicates the position of one of the seventy-three college students. Units on the vertical line denote rank in the test; horizontal units are ranks in psychology.

On the other hand, it seems, one could predict with less certainty the standing in the class of those students who are somewhat poor in the test. This may be due in part to the inadequacy of the test itself, in part to the inequality of interest in psychology. Cases 1 and 2 are typical of those students whose class work represents their best effort. These cases are selected because they are the only ones falling within the writer's experience. A careful analysis of the individual records, if possible, might reveal results of significance.

While the results indicate that the test as used by the different investigators reveals some sort of native ability, just what this ability is and to what extent it is revealed remains to be seen. Certainly, results of various experimenters up to date are not comparable, nor will they be until identically the same test is given with the same method of presenting and scoring.

III.

Previous Efforts toward Standardization

The first attempt to meet this need of standardization was made by Woodworth and Wells[1] in 1911. After testing six subjects with a long list of words, forty words were selected, which in turn were tried with forty other subjects. A few more words were substituted from tests of a few subjects, then the revised collection was tried with thirteen fresh subjects (all college and graduate students) and a few more minor corrections introduced.

In the experiment the four lists of ten stimulus words were presented visually but the time of the single reaction as well as the total time was roughly taken.

An attempt was made to have the halves of the list of equal difficulty, and since it was found impossible to prepare a list of twenty stimuli of equal difficulty, the words were combined in pairs, "so that pairs should be of equal difficulty, as judged by the sum of the reaction times to the two members of each pair." One pair, for instance, consisted of the hardest and the easiest word in the list and another pair of two words of medium difficulty.

In the event that the test might be given with a time limit, the authors have placed the words of medium difficulty in the list where most of the subjects will be stopped, namely, from about the eighth to the sixteenth word. "If then the time limit is so chosen that the great majority of subjects shall be stopped in this list, the separate words may, without much error on the average, be counted as equal units."

The test as given by Woodworth and Wells is scored only on the basis of time. The words were so selected that none of the subjects could fail to have a perfect accuracy score. As such, it is, as the authors intended, merely a test of the speed of association.

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[1] Woodworth, R. S., and Wells, F. L., "Association Tests," *Psychol. Monog.,* 1911, XIII.

In 1916 a further attempt was made by King and Gold[2] to standardize the test. The four lists of twenty easy words and the four lists of twenty hard words, as used by Simpson,[3] were presented individually to nine faculty members, twenty-three graduare students, forty-seven seniors, and twenty-one juniors of the Departments of Education and Psychology in the University of Iowa.

The subjects were instructed to take one list at a time, go down the list and name orally the opposite of each word in rapid succession and to avoid wherever possible prefixing a syllable to the stimulus word. The time was recorded for each list separately and the responses were taken down in shorthand.

The easy and hard opposites were scored differently. In the case of the easy opposites a credit of one, one-half, or zero was given to responses, and the penalty for an omitted word was four seconds. To the various responses to the hard opposites, credits of one, two-thirds, one-third, and zero were assigned, and an omitted word or incorrect word was penalized eighteen seconds. Regardless of the fact that the words were of varying difficulty, the penalty remained the same, namely, four seconds for easy words and eighteen seconds for hard words.

On the basis of these results (one hundred records for each word) the percent of failures for each word was computed. For each stimulus is recorded the value in terms of accuracy percentage as well as the acceptable responses and the frequency of each.

In the work of Harry A. Greene[4] we find the first attempt to assign to each word a point value based on its relative difficulty. Greene presented the stimuli used by King and Gold[5] to two groups of freshmen in the University of Iowa in the fall of 1916-1917. Nine hundred and ninety individuals were tested by the first half of the list and seven hundred and ten by the second half. The words were graded by the King and Gold standardization with the exception that words given two-thirds credit by them were given one-half credit and those receiving one-third credit were scored wrong.

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[2] King, Irving, and Gold, Hugo, "A Tentative Standardization of Certain Opposites Tests," *Jour. Educ. Psychol.,* 1916, VII, 459-482.

[3] Simpson, Benjamin R., *Op. cit.*

[4] Greene, Harry A., "A Standardization of Certain Opposites Tests," *Jour. Educ. Psychol.,* 1918, IX, 559-566.

[5] King, Irving, and Gold, Hugo, *Op. cit.*

The percentage of failures was then determined by allowing a value of one unit for correct responses and one-half for half-correct responses and subtracting this total from nine hundred and ninety. In the case of those words from the last half of the list for which there were only seven hundred and ten responses available, these totals were increased in the proportion of nine hundred and ninety to seven hundred and ten, thus making all the words in the list comparable.

By reading directly from the table based upon the area of the probability curve and assuming that the base line is broken arbitrarily at +3 sigma, the percentage scores were changed into percentile values. These values were then totaled and each value in turn divided by the total, thus converting the percentile values into relative point values. The points were based on accuracy alone, no account being taken of time.

IV.

THE SELECTION OF STIMULI FOR THE PRESENT INVESTIGATION

At the very outset, the writer was confronted with the problem of the method in which the test was to be presented. Chiefly because of the opportunity it afforded of studying each word individually, the oral method was chosen. Each word thus became a unit. The list could be lengthened or shortened at will without influencing to any appreciable extent the words retained. Let it be held in mind that at this point our interest was two-fold, namely, the selection of suitable stimuli and the computation of the value in points to be assigned to each word.

To have given the test in groups would have simplified the scoring and would have dispensed with much effort, but the attendent disadvantages made it necessary to abandon this method as a possible choice.

In the first place, it was intended that the test should be more difficult than previous tests of this character. This meant the substitution of entirely new stimuli, stimuli to be acquired only by the slow process of trial and error. Furthermore it was encumbent upon the writer, due to the small number of subjects at her disposal, to avoid a method which would involve discarding the entire record of a subject because of the use of one or more undesirable stimuli. As given, each word was a problem apart from every other word and only the records of those words not in the list as finally decided upon, were thrown into the discard.

If the group method is to be employed, a decision must be made as to whether time, accuracy, or a combination of both will be considered a measure of the difficulty of the word. Time considered alone, the test becomes one largely of speed of association. If the test is to be given with a time limit, the individual responses lose their identity as units and the percentage of failures per stimulus will vary with the time allowed. For instance, if the time limit is reduced from six to three minutes, the percentage of failures will vary considerably, particularly in the case of the more difficult words which should be placed at the end of the list. Thus one can see how a shortened time limit might give identical accuracy scores with words of unequal difficulty.

To illustrate the effect of varying the time limit not only upon the percentage of failures but also upon the nature of the responses themselves, let us consider the responses to the word "sacred" given, first, by a group of fifty-six students tested orally and individually, allowing ten seconds for the response, second, by another group of fifty-six students similarly tested, and third, by a group of fifty-six who were allowed only six minutes to write the opposites to the list of sixty-eight words eventually retained. In the table below is shown the number of failures and the exact responses given by the three groups of fifty-six. Notice the greater number of failures in Group III and also the homogeneity of responses. This may be explained by the fact that the word is not reached in the list or that uncertain words are passed up for those in which the subject feels confident of success.

On the other hand to lengthen the time limit considerably, while it would give more nearly correct accuracy scores, would be unfair to the individuals tested, if these same records were to be used as the basis for norms. With a lengthened time limit, students would be able to complete the test at different intervals. Evidently of two students, both of whom make perfect scores, the one finishing the work in the shorter period is the more efficient. But we should have no measure of this efficiency.

To give the test as a group test without taking into consideration the time consumed, would seem to imply either that additional time would fail to increase the accuracy percentage, or that without exception the more difficult a word, the longer the time required to think of an opposite. The former assumption is probably true within certain limits. It is conceivable that a time limit might be selected beyond which there would be no improvement, but it is obvious that the time limit might be so shortened

TABLE VIII

Showing the Different Responses Given as an Opposite to the Word "Sacred" when the Time Limit is Changed

	Number of Times Each Response is given by the Several Groups		
Different Responses Given by the Groups	Group I	Group II	Group III
Common	2	1	1
Secular	0	2	4
Profane	5	7	4
Sinful	0	2	1
Worldly	0	2	1
Unholy	9	1	2
Irreverent	2	3	1
Wicked	2	2	1
Sacrilegious	3	7	2
Unsacred	8	5	0
Vulgar	1	3	0
Public	2	1	0
Mean	0	1	0
Ungodliness	0	1	0
Heathen	0	1	0
Sacrilege	0	1	0
Obnoxious	1	0	0
Ungodly	1	0	0
Unnoticed	1	0	0
Idolatrous	1	0	0
Irreligious	1	0	0
Infidel	1	0	0
Hypocritical	1	0	0
Failure to Respond	15	16	39
Number of Different Responses per Group	16	16	9

that the accuracy scores would be greatly affected. In general it is true that words with a high accuracy score have a correspondingly low time score, but a glance at Tables XI and XII will show that such is not always the case, for words with different accuracy scores may have identical time scores and words with identical accuracy scores have different time scores. However, the correlation between the two is undoubtedly high.

To give the test individually and record the time for the total list has all the disadvantages in point of labor and none of the advantages that accrue when the test is given individually and orally.

Having determined the procedure to be followed, the writer began in the fall of 1915 the task of selecting suitable stimuli for the present investigation. After eleven records were obtained with a list containing the three hundred and twenty-three words used by previous experimenters and forty new words, the list was divided and during the remainder of the year two lists were used which consisted on the average of about one hundred and fifty words each. From time to time words found inadequate were dropped and others substituted as they occurred to the writer. Hence the inequality in the number of subjects tested with a given word. In this manner one hundred and thirty-nine students at George Peabody College for Teachers were tested during the school year 1915-1916.

Commonly misunderstood words were weeded out as were those with an accuracy score of one hundred percent. Likewise attempts were made to discard those words which had an opposite formed by adding the prefix "un" in frequent and reputable use. Meanwhile original words were subjected to the same process of examination and elimination.

The point of interest was the individual word, but as these data were to be used in another connection care was taken that the conditions remain constant throughout. Since each test was given individually, it was an easy matter to change the order of the stimuli and thus avoid practice effects. The reaction time in fifths of a second was recorded with a stop-watch along with the response. The following directions were read to each subject:

"As soon as I read a word you are to give me the best opposite you can think of. For instance, if I read 'black' you are to say 'white.' Do not give me phrases, nor words beginning with the prefix 'non.' The word you give must belong to the same part of speech as the word in the list. Your time will be recorded, so answer each word as quickly as possible. Under no circumstances will I allow you over ten seconds for a word. Let me show you how long ten seconds really is. (Experimenter illustrates with stop-watch.) Remember in each case to respond as quickly as possible. Do you understand what you are to do?"

In the fall of 1918[1] the work was resumed. It was decided expedient to use only one list as the number of possible subjects to be obtained at Peabody was small. Two lists would of course cut the records for each word in two. Besides the second list contained for the most part opposites of the first. Of the one hundred words with which the work was begun in the fall, thirty-two were dropped, leaving the sixty-eight which comprise the list as it now stands. These words, arranged in the ascending order of difficulty, are given below. The original words are given in italics. Full, *Negative,* After, Dim, Blunt, Success, *Pessimistic,* Joy, Public, Profit, Spend, Always, Graceful, Strength, Ancient, Expand, Barbarous, Hinder, Despondent, Vague, Fertile, Doubtful, Injurious, Busy, *Abstract,* Advance, Foreign, Create, Simple, *Extravagant,* Aristocratic, Rare, Dangerous, Slovenly, Defective, Stingy, Reveal, Diligent, Join, Impoverish, Permanent, Elation, Sinful, Obnoxious, Conservative, Victorious, Obscure, Proficient, Rigid, Repulsion, Imaginary, Permit, *Orthodoxy, Analytical, Extrinsic, Sacred, Dynamic, Loquacious, Heterogeneous, Spurious,* Disastrous, *Facility,* Pride, Result, Adroit, *Parsimony,* Suave, *Esoteric.*

One hundred and twelve subjects were tested with this list. This means that later in determining the relative difficulty of the stimuli, the calculations are based on at least one hundred and twelve records for each word, varying up to one hundred and eighty-seven for others.

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[1] This research was conducted under the supervision of Dr. Edward K. Strong up to this point, thereafter under the guidance of Dr. Joseph Peterson.

V.

THE CHOICE OF THE ACCEPTABLE RESPONSES

The next step was to standardize and evaluate the responses. In order to facilitate matters, beneath each stimulus was written the long list of words which had been given as opposites by those subjects experimented upon. The credit due each of these responses was determined by five judges, including the writer. They were besides the writer:

Miss Lula O. Andrews, Professor of English; Miss Mary Clay Hiner, Instructor in English; Mr. S. H. Phelps, Instructor in School Administration, and Dr. Joseph Peterson, Professor of Psychology, all of George Peabody College.

Each judge was ignorant of the credit assigned any word by any other judge. The following directions, a copy of which was handed each judge, will make the matter clear:

Directions for Grading Responses

I. Make use of any available source of information such as the dictionary or book of antonyms.

II. The responses are to be graded with a grade of "one," which means an exact opposite, or "one-half," which means only an approximate opposite, or "zero," which means a failure.

III. More than one response to a word may be given a credit of "one."

IV. Words belonging to a different part of speech are to be graded "zero," also words with the prefix "non."

V. If a word belongs to the same part of speech and is nearly an opposite, give it "one-half" credit.

VI. Add any response that may suggest itself to you and grade it as directed above.

The new words suggested were in turn passed on by the other four judges. In addition, when later the test was converted into a group test and hundreds of records secured, a number of different responses, given by those tested, were submitted to the same process of evaluation.

The credits assigned each response were then averaged and if the result was nearer "zero" than "one-half," the word received no credit; if nearer "one-half" than "zero" or "one" it received "one-half" credit; and if nearer "one" than "one-half," it was given a credit of "one." For instance the response "young" in answer to "ancient" received credits as follows:

TABLE IX

	I	II	III	IV	V	Total	Aver.	Credit Assigned
Credits given to "young" by five judges..	1	½	0	0	½	2	.4	½

On the following pages is to be found in Column II the stimulus word, in Column III the responses which are due a credit of "one' (the full value assigned to the word), and in Column IV those responses which receive only "one-half" credit (half the value assigned the word). The value of the word is given in points in Column I. The manner in which we arrived at these values will be discussed in the following section.

TABLE X

A List of the Stimuli with Assigned Values and Accepted Responses

Value	Stimulus Word	Correct Responses	Half Correct Responses
1	Full	Empty	Meagre
1	Negative	Affirmative Positive	Assertive
1	After	Before Preceding	Fore
1	Dim	Bright Clear Distinct Luminous	Light Plain Vivid
1	Blunt	Keen Pointed Sharp Tactful	Acute Polite Sensitive Suave

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
1	Success	Defeat Disaster Failure	Downfall Loss
1	Pessimistic	Optimistic	Joyful
1	Joy	Gloom Grief Misery Sadness Sorrow	Depression Despondency Displeasure Pain Woe
2	Public	Private	Domestic Personal Secluded Secret
2	Profit	Loss	Deficit Lose
2	Spend	Earn Hoard Husband Keep Save	Accumulate Get Hold Make Receive
2	Always	Never	Infrequently Seldom
2	Graceful	Awkward Clumsy Gawky Ungainly	Uncouth Ungraceful Unsightly
2	Strength	Feebleness Frailty Weakness	Delicacy Insecurity
3	Ancient	Modern	New Present Recent Young
3	Expand	Contract Decrease Diminish Shrink Shrivel	Compress Narrow
3	Barbarous	Civilized Humane	Chivalrous Civil Cultured Educated Gentle Kind Polite

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
3	Hinder	Aid Assist Expedite Fore Forward Further Facilitate Help Promote	Advance Encourage
3	Despondent	Buoyant Cheerful Ecstatic Elated Exuberant Glad Happy Hopeful Joyful Jubilant	Bright Encouraged Exhilarated Gay Hilarious Joyous Merry Optimistic Sanguine
3	Vague	Clear Definite Distinct Exact Plain Specific	Apparent Concise Explicit
3	Fertile	Arid Barren Poor Sterile Unproductive	Fruitless Impotent Impoverished Infertile Unimaginative
4	Doubtful	Assured Certain Evident Hopeful Sure	Apparent Believable Clear Confident Credible Known Positive True Truthful Unquestioned
4	Injurious	Advantageous Beneficial Helpful Innocuous Wholesome	Harmless Healthful Safe Uninjurious
4	Busy	Idle Unemployed Unoccupied	Dull Inactive Indolent Loafing

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
4	Abstract	Concrete	Specific
4	Advance	Decline Recede Retard Retire Retreat Retrograde Withdraw	Degrade Hinder Withhold
4	Foreign	Domestic Germane Native Pertinent	American Home Indigenous Local Natural
4	Create	Annihilate Demolish Destroy	Abolish Disintegrate Dismember Exterminate Obliterate Undo Waste
4	Simple	Complex Complicated Compound Elaborate Intricate Ornate Wise	Bright Confusing Difficult Gorgeous Grand Hard Learned Sensible Smart
4	Extravagant	Economical Frugal Miserly Niggardly Parsimonious Saving	Careful Close Conservative Economizing Penurious Stingy Thrifty
4	Aristocratic	Bourgeois Common Democratic Plebeian	Humble Low Lowly Ordinary
4	Rare	Abundant Common Dense Frequent Numerous Plentiful Plenteous Usual	Commonplace Often Ordinary Profuse Regular Occasional
4	Dangerous	Harmless Safe	Peaceful

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
5	Slovenly	Neat Neatly Tidy Tidily	Careful Carefully Gracefully Precise Trim
5	Defective	Complete Faultless Normal Perfect Sound Whole	Correct Effective Good Healthy
5	Stingy	Generous Lavish Liberal Prodigal	Bounteous Bountiful Extravagant Freehearted Magnanimous Unselfish Unsharing Wasteful
5	Reveal	Conceal Hide Obscure	Cover Secrete Suppress Withhold
5	Diligent	Dilatory Indolent Lazy Slothful	Careless Negligent Inattentive Idle Shiftless
5	Join	Abandon Disjoin Disconnect Dismember Divide Part Separate Sever Sunder	Detach Disassociate Disband Leave Resign Tear Undo Untie Withdraw
6	Impoverish	Enrich Replenish	Aggrandize Fertilize Nourish Strengthen
7	Permanent	Ephemeral Evanescent Fleeting Passing Temporary Transient Transitory	Ephemerate Fluctuating Impermanent Perishable Shifting Transitional Unsubstantial

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
7	Elation	Dejection Depression Despair Despondence Despondency	Grief Sadness Shame Sorrow
7	Sinful	Blameless Righteous Sinless	Godly Holy Innocent Just Religious Perfect Pious Pure Upright Virtuous
7	Obnoxious	Agreeable Beneficial Inoffensive Pleasing	Acceptable Attractive Congenial Desirable Harmless Helpful Likable Pleasant Winning
7	Conservative	Extreme Liberal Progressive Radical	Aggressive Extravagant Extremist Wasteful
7	Victorious	Conquered Defeated Vanquished	Beaten Unsuccessful Unvictorious Whipped
7	Obscure	Clear Conspicuous Eminent Lucid Plain Prominent Renowned Reveal	Apparent Bright Disclose Distinct Evident Famous Noticeable Notorious Obvious Unambiguous
8	Proficient	Deficient Inapt Unskilled Unskillful	Backward Incapable Incompetent Inefficient Lacking Unprepared

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
8	Rigid	Elastic Flexible Lax Lenient Limber Limp Plastic Relaxed Supple Yielding	Easy Flabby Flaccid Loose Pliable
8	Repulsion	Attraction Cohesion	Acceptance Agreeableness Admiration Love
9	Imaginary	Real	Actual Prosaic Realistic True
9	Permit	Forbid Prevent Refuse Restrain	Deny Disallow Disapprove Object Prohibit
9	Orthodoxy	Heresy Heterodoxy	Catholicity Liberalism Unconventionality Unsoundness
10	Analytical	Synthetic Synthetical	Unanalytical
10	Extrinsic	Intrinsic	Essential Internal
11	Sacred	Defiled Profane Secular Unholy	Common Desecrated Sacrilegious Unconsecrated Ungodly Vulgar
11	Dynamic	Inert Static	Potential Powerless Weak
11	Loquacious	Laconic Reticent Taciturn Silent	Mute Reserved Quiet Untalkative
12	Heterogeneous	Homogeneous	Alike Similar

TABLE X—Continued

Value	Stimulus Word	Correct Responses	Half Correct Responses
12	Spurious	Authentic Genuine Real	Actual Legitimate Pure Sound True Truthful Unadulterated
13	Disastrous	Advantageous Beneficial Helpful Safe	Favorable Fortunate Gainful Harmless Lucky Prosperous
14	Facility	Difficulty	Awkwardness Clumsiness Disability Effort Inconvenience
14	Pride	Humility Lowliness Meekness	Debasement Degradation Humbleness Humiliation
15	Result	Causation Cause	Beginning Commencement Origin Purpose Start
15	Adroit	Awkward Clumsy Inexpert Maladroit Unskillful	Crude Unskilled
17	Parsimony	Extravagance Generosity Lavishness Liberality Prodigality	Freeheartedness Magnanimity Wastefulness
22	Suave	Brusque Impolite Tactless Unpolished	Abrupt Blunt Crude Gruff Harsh Rough Rude Uncouth Undiplomatic Unpleasant Untactful
26	Exoteric	Esoteric	Private

VI.

THE COMPUTATION OF THE RELATIVE DIFFICULTY OF THE STIMULI

As stated previously, when the test was administered, each response given by the subject as well as the reaction time of that response was recorded. On the basis of these records the following data were tabulated for each stimulus: the different responses, the reaction time of each response, and the failures to respond. Records were so kept that information could be obtained not only regarding the number of subjects giving a certain response but also regarding the reaction times of that response. For instance, instead of merely indicating the number of people who gave "young" as an opposite to "ancient," the records show that "young" was given one time in six-fifths of a second, another time in nine-fifths, another in seven, etc.

Furthermore, in order to ascertain when a sufficiently large number of subjects had been tested for the results to be reliable and to be able to indicate the extent of this reliability, as determined by the change brought about by additional sampling, separate records were kept of all tests made prior to the fall of 1918. These will be designated as Group I. Group II consists of the fifty-six records secured in the early fall of 1918, and Group III of the remaining fifty-six records. Since some of the stimuli were added to the list at different times the number of records of subjects in Group I varies from zero to seventy-nine.

After the acceptable responses had been determined these record sheets were scored and the number of correct responses the number of half correct responses, and the number of failures, as well as the total of all three, were tabulated. The number of failures includes both the failures to give any opposite and the failures to give the correct opposite. These results are to be found in Table XI, columns III, IV, V and VI. Referring to this table, we read that for the word "full," there were in Group

I, sixty correct responses, no half correct responses, and three failures, making a total of sixty-three records for that word obtained before the fall of 1918. Reading further in Group II for the same word, we have fifty-four correct and one half correct responses with one failure, thus totaling fifty-six. In Group III we find the following distribution: fifty-five correct and one half-correct.

In computing the percentage of failures, to be found in column VII, two half-correct responses were considered equivalent to one failure. The formula will make clear the procedure followed.

$$\text{Percentage of failures} = \frac{F + \frac{H}{2}}{N} \text{ in which}$$

F = the number of failures,
H = the number of half-correct responses,
N = the total number tested.

Applying this formula to the word "full" we have in Group I,

$$\frac{3 + \frac{0}{2}}{63} = .047$$

Group II does not represent the percentage of failures in Group II alone but a combination of Groups I and II. Applying the formula again for the same word we have $\frac{4 + .5}{119} = .037$ in which 4 equals the sum of the failures in groups I and II, .5 equals half of the half-correct responses in groups I and II, and 119 is the sum of the total number tested. Similarly Group III represents the sum of groups I, II, and III.

This procedure of estimating the three different percentages of failures, instead of only one was adopted because it indicated the degree of reliability of the measure. Very radical changes obviously would mean little reliability. Efforts were made to have our sampling as representative of all the students as possible. Therefore the number tested include graduate students as well as members of the four different classes of undergraduates.

TABLE XI

Data from Which the Percentage of Failures for Each Stimulus was Computed

I Stimulus	II Group	III Number of Correct Responses	IV Number of Half-Correct Responses	V Number of Failures	VI Total Number Tested	VII Percentage of Failures
Full	I	60	0	3	63	.047
	II	54	1	1	56	.037
	III	55	1	0	56	.028
Negative	I	48	0	2	50	.040
	II	53	0	3	56	.047
	III	56	0	0	56	.030
After	I	71	0	3	74	.040
	II	55	0	1	56	.030
	III	53	0	3	56	.037
Dim	I	66	8	1	75	.066
	II	50	3	3	56	.072
	III	42	14	0	56	.089
Blunt	I	60	0	3	63	.947
	II	48	2	6	56	.084
	III	50	0	6	56	.091
Success	I	59	0	4	63	.063
	II	51	1	4	56	.071
	III	44	3	9	56	.108
Pessimistic	I	47	0	2	49	.040
	II	49	1	6	56	.080
	III	47	0	9	56	.108
Joy	I	65	0	3	68	.044
	II	49	3	4	56	.068
	III	48	2	6	56	.086
Public	I	63	0	5	68	.073
	II	46	3	7	56	.108
	III	49	3	4	56	.105
Profit	I	55	7	5	67	.126
	II	52	0	4	56	.101
	III	41	5	10	56	.139
Spend	I	46	9	8	63	.198
	II	51	1	4	56	.142
	III	51	1	4	56	.122
Always	I	52	1	10	63	.166
	II	44	0	12	56	.188
	III	43	2	11	56	.197

TABLE XI—Continued

I Stimulus	II Group	III Number of Correct Responses	IV Number of Half-Correct Responses	V Number of Failures	VI Total Number Tested	VII Percentage of Failures
Graceful	I	50	13	5	68	.169
	II	44	7	5	56	.161
	III	45	4	7	56	.161
Strength	I	56	0	8	64	.125
	II	43	0	13	56	.175
	III	41	0	15	56	.204
Ancient	I	33	26	3	62	.258
	II	32	22	2	56	.245
	III	40	14	2	56	.218
Expand	I	45	1	11	57	.201
	II	43	2	11	56	.207
	III	41	0	15	56	.227
Barbarous	I	57	11	0	68	.080
	II	34	17	5	56	.153
	III	34	12	10	56	.194
Hinder	I	52	3	13	68	.213
	II	44	0	12	56	.213
	III	39	5	12	56	.227
Despondent	I	48	12	3	63	.142
	II	37	15	4	56	.172
	III	39	8	9	56	.191
Vague	I	55	2	10	67	.164
	II	42	2	12	56	.195
	III	38	1	17	56	.231
Fertile	I	54	1	15	70	.221
	II	40	0	16	56	.250
	III	47	0	9	56	.222
Doubtful	I	38	9	10	57	.254
	II	39	9	8	56	.238
	III	38	10	8	56	.236
Injurious	I	48	10	10	68	.220
	II	39	8	9	56	.225
	III	36	6	14	56	.249
Busy	I	39	4	24	67	.388
	II	35	1	20	56	.378
	III	41	1	14	56	.340
Abstract	I	0	0	0	0	.000
	II	35	2	19	56	.357
	III	33	4	19	56	.365

TABLE XI—Continued

I Stimulus	II Group	III Number of Correct Responses	IV Number of Half-Correct Responses	V Number of Failures	VI Total Number Tested	VII Percentage of Failures
Advance	I	48	0	10	58	.172
	II	32	4	20	56	.280
	III	34	1	21	56	.314
Foreign	I	37	10	6	53	.207
	II	34	10	12	56	.256
	III	34	10	12	56	.272
Create	I	50	3	14	67	.231
	II	38	1	17	56	.292
	III	35	2	19	56	.296
Simple	I	13	21	9	43	.453
	II	34	15	7	56	.343
	III	32	14	10	56	.328
Extravagant	I	41	8	7	56	.196
	II	42	6	8	56	.196
	III	35	9	12	56	.229
Aristocratic	I	52	4	12	68	.205
	II	34	5	17	56	.270
	III	32	1	23	56	.316
Rare	I	37	16	8	61	.262
	II	38	7	11	56	.260
	III	38	6	12	56	.262
Dangerous	I	35	1	15	51	.303
	II	36	0	20	56	.331
	III	35	0	21	56	.346
Slovenly	I	44	10	14	68	.279
	II	27	11	18	56	.342
	III	28	4	24	56	.380
Defective	I	47	6	15	68	.264
	II	38	6	12	56	.264
	III	27	8	21	56	322
Stingy	I	43	11	14	68	.286
	II	30	11	15	56	.322
	III	18	13	25	56	.397
Reveal	I	38	4	21	63	.365
	II	31	4	20	56	.378
	III	34	4	18	56	.371
Diligent	I	43	4	20	67	.328
	II	33	15	8	56	.304
	III	26	9	21	56	.351

TABLE XI—Continued

I Stimulus	II Group	III Number of Correct Responses	IV Number of Half-Correct Responses	V Number of Failures	VI Total Number Tested	VII Percentage of Failures
Join	I	33	11	11	55	.300
	II	38	0	18	56	.310
	III	30	7	19	56	.341
Impoverish	I	38	4	27	69	.420
	II	22	3	31	56	.492
	III	27	0	29	56	.500
Permanent	I	37	5	21	63	.373
	II	24	1	31	56	.462
	III	34	1	21	56	.437
Elation	I	33	10	19	62	.387
	II	17	3	36	56	.521
	III	18	3	35	56	.563
Sinful	I	20	40	8	68	.411
	II	13	25	18	56	.471
	III	17	19	20	56	.488
Obnoxious	I	43	11	13	67	.276
	II	14	22	20	56	.402
	III	16	14	26	56	.460
Conservative	I	39	3	27	69	.413
	II	15	15	26	56	.496
	III	14	15	27	56	.533
Victorious	I	43	4	24	67	.388
	II	22	9	25	56	.451
	III	24	8	24	56	.466
Obscure	I	27	4	26	57	.491
	II	25	3	28	56	.508
	III	25	6	25	56	.505
Proficient	I	18	30	15	63	.476
	II	16	18	22	56	.512
	III	14	13	29	56	.551
Rigid	I	27	14	16	57	.403
	II	17	18	21	56	.469
	III	14	18	24	56	.508
Repulsion	I	29	4	34	67	.537
	II	20	2	34	56	.577
	III	18	3	35	56	.600
Imaginary	I	22	4	28	54	.555
	II	21	2	33	56	.581
	III	20	2	34	56	.596

TABLE XI—Continued

I Stimulus	II Group	III Number of Correct Responses	IV Number of Half-Correct Responses	V Number of Failures	VI Total Number Tested	VII Percentage of Failures
Permit	I	28	12	28	68	.500
	II	24	7	25	56	.504
	III	24	8	24	56	.502
Orthodoxy	I	15	0	40	55	.727
	II	9	0	47	56	.783
	III	6	0	50	56	.820
Analytical	I	29	1	27	57	.482
	II	10	1	45	56	.646
	III	11	0	45	56	.698
Extrinsic	I	1	0	1	2	.500
	II	16	0	40	56	.706
	III	15	0	41	56	.719
Sacred	I	24	4	30	58	.551
	II	15	7	34	56	.609
	III	10	11	35	56	.647
Dynamic	I	5	4	30	39	.820
	II	3	4	49	56	.873
	III	7	2	47	56	.867
Loquacious	I	14	20	28	62	.612
	II	13	3	40	56	.673
	III	13	5	38	56	.689
Heterogeneous	I	2	0	1	3	.333
	II	9	4	43	56	.779
	III	12	0	44	56	.782
Spurious	I	6	12	31	49	.755
	II	4	3	49	56	.833
	III	4	3	49	56	.857
Disastrous	I	18	2	30	50	.620
	II	15	6	35	56	.650
	III	21	2	33	56	.635
Facility	I	10	1	34	45	.766
	II	6	3	47	56	.821
	III	5	0	51	56	.853
Pride	I	17	3	53	73	.746
	II	8	2	46	56	.786
	III	6	1	49	56	.816
Result	I	15	15	32	62	.636
	II	10	6	40	56	.698
	III	4	6	46	56	.755

TABLE XI—Continued

I Stimulus	II Group	III Number of Correct Responses	IV Number of Half-Correct Responses	V Number of Failures	VI Total Number Tested	VII Percentage of Failures
Adroit	I	19	2	40	61	.672
	II	7	3	46	56	.756
	III	3	0	53	56	.817
Parsimony	I	11	2	35	48	.750
	II	7	0	49	56	.816
	III	6	6	44	56	.823
Suave	I	2	10	34	46	.847
	II	2	9	45	56	.867
	III	1	8	47	56	.882
Exoteric	I	3	0	49	52	.942
	II	1	0	55	56	.962
	III	0	0	56	56	.975

Since the value of the stimuli was to be in terms of both accuracy and speed, the median time of all responses, both correct and half correct, was computed. The time score taken with a stop-watch represents fifths of a second. As in the case of the accuracy score, three time scores were reckoned for each word, the last score representing the combined time of all three groups. See column III, Table XII. The percent of failures of the preceding table is copied in order to make clear the process by which the values of the several stimuli are reached.

To arrive at the relative difficulty of the stimuli, the percenttage of failures was multiplied by the median time. If credit is to be given for both measures, some more or less arbitrary scheme must be adopted. This procedure seemed justifiable since by it words of equal accuracy scores received different point values if the difference in time varied to any appreciable extent. This was precisely what was desired. Any method which covered up this difference was to be avoided.

In order to determine a point value for the stimuli, the standard deviation of the different values, as indicated in the fourth column of the following table, was obtained. Beginning at the average and calling it zero, steps of one-fifth standard deviation were then made, positively and negatively. These steps being equal in a sense, the furtherest negative step was assigned a value of one, the next two, and so on up to twenty-six, the most difficult word in the list. These point values are given in the fifth column of Table XII.

In selecting the stimuli for the completed test, those words which had received a hundred percent accuracy score were discarded, for thus we were better enabled to locate a zero point. Obviously we cannot find or infer the place where the ability to give opposites begins, as we can in the physical sciences for weight or length. Therefore the zero point will of necessity be an arbitrary one selected to represent very little of the trait in question. In eliminating all words with a hundred percent accuracy score, but retaining those next in difficulty, we assume that a college student who is unable to score a point on the test as it now stands has zero ability in naming opposites. Since we have located the distance from the median in terms of standard deviation, we have equally difficult steps. Roughly we assigned to the furtherest negative step a value of one. Since we are not concerned as were Woody[1] and Hering[2] with finding the distances between different grades or groups of pupils, it seems impracticable to be too particular about the absolute point of the zero. In addition any error in slightly misplacing the point might be of less importance than that made in weighting time and accuracy.

It is regretted that, especially in the case of the more difficult words, the measure of time is based on so small a number of records. As an indication of the reliability of the median time, we have computed the median deviation and coefficient of variability for each word. The probable error of the median is calculated by the formula, P. E. med. $= \dfrac{5\ Q\ \text{dis}}{4\sqrt{n}}$.[3]

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[1] Woody, Clifford, "Measurements of Some Achievements in Arithmetic," *Col. Univ. Cont. Educ.*, 1916, LXXX.

[2] Hering, John P., "Derivation of a Scale to Measure Abilities in Scientific Thinking," *Jour. Educ. Psychol.*, 1919, IX, 417-431.

[3] Thorndike, E. L., "Mental and Social Measurements," New York, 1916, p. 195.

TABLE XII

The Point Value of the Stimuli Computed from Table IX

I	II	III	IV	V	VI	VII	VIII
Stimulus	Percent of Failures	Median Time	Relative Value	Point Value	Median Deviation	Coefficient of Variability	Probable Error of Median
Full	.047	7	.329				
	.037	6	.222				
	.028	7	.209	1	1.48	.21	.14
Negative	.040	7	.280				
	.047	7	.329				
	.030	7	.210	1	1.22	.17	.12
After	.040	6	.240				
	.030	7	.210				
	.037	7	.259	1	1.20	.17	.11
Dim	.066	8	.528				
	.072	7	.504				
	.089	7	.623	1	1.64	.23	.15
Blunt	.047	6	.282				
	.084	7	.588				
	.091	7	.637	1	1.40	.20	.13
Success	.063	6	.378				
	.071	7	.497				
	.108	6	.648	1	1.50	.25	.14
Pessimistic	.040	6	.240				
	.080	6	.480				
	.108	6	.648	1	1.11	.18	.11
Joy	.044	7	.308				
	.068	8	.544				
	.086	8	.688	1	2.08	.26	.20
Public	.073	7	.511				
	.108	7	.756				
	.105	8	.840	2	2.03	.25	.19
Profit	.126	7	.882				
	.101	8	.808				
	.139	8	1.112	2	2.26	.28	.22
Spend	.198	10	1.980				
	.142	10	1.420				
	.122	10	1.220	2	2.80	.28	.27
Always	.166	8	1.328				
	.188	8	1.504				
	.197	8	1.576	2	1.90	.23	.19
Graceful	.169	10	1.690				
	.161	10	1.610				
	.161	10	1.610	2	3.36	.33	.32

TABLE XII—Continued

I Stimulus	II Percent of Failures	III Median Time	IV Relative Value	V Point Value	VI Median Deviation	VII Coefficient of Variability	VIII Probable Error of Median
Strength	.125	7	.875				
	.175	8	1.400				
	.204	8	1.632	2	1.95	.24	.20
Ancient	.258	8	2.064				
	.245	7.5	1.837				
	.218	8	1.744	3	2.30	.25	.22
Expand	.201	9	1.809				
	.297	8	1.656				
	.227	8	1.816	3	1.28	.16	.13
Barbarous	.080	11	.880				
	.153	11	1.683				
	.194	11	2.134	3	2.90	.26	.28
Hinder	.213	9	1.917				
	.213	10	2.130				
	.227	10	2.270	3	3.48	.34	.36
Despondent	.142	14	1.988				
	.172	12	2.064				
	.191	12	2.292	3	3.54	.29	.35
Vague	.164	9	1.476				
	.195	10	1.950				
	.231	11	2.541	3	3.23	.29	.34
Fertile	.221	12	2.652				
	.250	12	3.000				
	.222	12	2.664	3	3.85	.32	.40
Doubtful	.254	12	3.048				
	.238	12	2.858				
	.236	12	2.832	4	3.89	.32	.40
Injurious	.220	11	2.420				
	.225	12	2.700				
	.249	12	2.988	4	4.47	.37	.46
Busy	.388	10	3.880				
	.378	10	3.780				
	.340	9	3.060	4	2.64	.29	.30
Abstract	.000	0	0.000				
	.357	9	3.213				
	.365	8.5	3.102	4	2.10	.24	.30
Advance	.172	9	1.548				
	.280	9	2.520				
	.314	10	3.140	4	2.90	.29	.33

TABLE XII—Continued

I Stimulus	II Percent of Failures	III Median Time	IV Relative Value	V Point Value	VI Median Deviation	VII Coefficient of Variability	VIII Probable Error of Median
Foreign	.207	12	2.484				
	.256	12	3.072				
	.272	12	3.264	4	3.80	.31	.45
Create	.231	10	2.310				
	.292	11	3.212				
	.296	11	3.256	4	3.31	.30	.36
Simple	.453	8	3.624				
	.343	10	3.430				
	.328	10	3.280	4	3.23	.32	.28
Extravagant	.196	14	2.744				
	.196	15	2.940				
	.229	15	3.435	4	4.14	.27	.43
Aristocratic	.205	12	2.460				
	.270	11	2.970				
	.316	11	3.476	4	4.20	.38	.46
Rare	.262	14	3.668				
	.260	14	3.640				
	.262	14	3.668	4	3.39	.24	.35
Dangerous	.303	11	3.333				
	.331	11	3.641				
	.346	11	3.806	4	3.75	.34	.45
Slovenly	.279	11	3.069				
	.342	12	4.104				
	.380	11	4.180	5	3.62	.32	.63
Defective	.264	13	3.432				
	.264	13	3.432				
	.322	13	4.186	5	5.29	.40	.58
Stingy	.286	10	2.860				
	.322	12	3.864				
	.397	11	4.367	5	3.34	.30	.37
Reveal	.365	11	4.015				
	.378	11	4.158				
	.371	12	4.452	5	3.83	.31	.44
Diligent	.328	13	4.264				
	.304	13	3.952				
	.351	13	4.563	5	3.97	.30	.43
Join	.300	14	4.200				
	.310	13	4.030				
	.341	14	4.774	5	4.90	.35	.56

TABLE XII—Continued

I Stimulus	II Percent of Failures	III Median Time	IV Relative Value	V Point Value	VI Median Deviation	VII Coefficient of Variability	VIII Probable Error of Median
Impoverish	.420	12	5.040				
	.492	11	5.412				
	.500	11	5.500	6	.341	.31	.49
Permanent	.373	13	4.849				
	.462	13	6.006				
	.437	14	6.118	7	4.50	.32	.55
Elation	.387	10	3.870				
	.521	12	6.262				
	.563	12	6.756	7	3.79	.31	.51
Sinful	.411	13	5.343				
	.471	16	7.536				
	.488	14	6.832	7	5.10	.36	.64
Obnoxious	.276	13	3.588				
	.402	14	5.628				
	.460	15	6.900	7	5.36	.35	.61
Conservative	.413	11	4.543				
	.496	11	6.448				
	.533	13	6.929	7	4.30	.33	.53
Victorious	.388	14	5.432				
	.451	15	6.765				
	.466	15	6.990	7	4.75	.31	.56
Obscure	.491	12	5.892				
	.508	13	6.604				
	.505	14	7.070	7	6.06	.43	.79
Proficient	.476	11	5.236				
	.512	13	6.656				
	.551	13	7.163	8	5.45	.41	.65
Rigid	.403	15	6.045				
	.469	15	7.035				
	.508	15	7.620	8	4.97	.33	.59
Repulsion	.537	11	5.907				
	.577	13	7.501				
	.600	13	7.800	8	5.30	.40	.75
Imaginary	.555	11	6.105				
	.581	12	6.972				
	.596	14	8.344	9	4.56	.32	.67
Permit	.500	16	8.000				
	.504	16	8.064				
	.502	17	8.534	9	6.50	.38	.80

TABLE XII—Continued

I Stimulus	II Percent of Failures	III Median Time	IV Relative Value	V Point Value	VI Median Deviation	VII Coefficient of Variability	VIII Probable Error of Median
Orthodoxy	.727	11	7.997				
	.783	11	8.613				
	.820	11	9.020	9	2.50	.22	.57
Analytical	.482	16.5	7.953				
	.646	14	9.044				
	.698	14	9.772	10	4.27	.30	.74
Extrinsic	.500	9	4.500				
	.706	17	12.000				
	.719	14	10.066	10	5.30	.37	1.17
Sacred	.551	15	8.265				
	.609	16	9.744				
	.647	16	10.352	11	6.17	.38	.91
Dynamic	.820	12	9.840				
	.873	12	10.476				
	.867	12	10.404	11	3.75	.31	.93
Loquacious	.612	15	9.180				
	.673	15	10.095				
	.689	16	11.024	11	5.08	.31	.76
Heterogeneous	.333	14.5	4.828				
	.779	13	10.127				
	.782	15	11.730	12	4.88	.32	1.17
Spurious	.755	14	10.570				
	.833	14	11.662				
	.857	14	11.998	12	5.50	.39	1.21
Disastrous	.620	17	10.540				
	.650	19	12.350				
	.635	20	12.700	13	7.08	.35	1.10
Facility	.766	16	12.256				
	.821	18	14.778				
	.853	16	13.648	14	7.00	.43	1.75
Pride	.746	16	11.936				
	.786	17	13.362				
	.816	17	13.872	14	5.88	.34	1.20
Result	.636	20	12.740				
	.699	22	15.378				
	.755	20	15.100	15	8.00	.40	1.33
Adroit	.672	16	10.752				
	.756	17	12.852				
	.817	18.5	15.114	15	6.23	.33	1.33

TABLE XII—Continued

I Stimulus	II Percent of Failures	III Median Time	IV Relative Value	V Point Value	VI Median Deviation	VII Coefficient of Variability	VIII Probable Error of Median
Parsimony	.750	25	18.750				
	.816	22	17.952				
	.823	21	17.183	17	6.60	.31	1.45
Suave	.847	24.5	20.751				
	.867	25	21.675				
	.882	25	22.050	22	9.17	.36	2.02
Exoteric	.942	36	33.912				
	.962	27.5	26.455				
	.975	27.5	26.812	26	9.50	.34	5.93

VII.

THE CONVERSION INTO A GROUP TEST

In order to make it possible for even the inexperienced to use the test with facility, it was converted into a group test. Thus, obviously, much time in administering and labor in scoring were dispensed with. In addition, the personal element became almost negligible. The words were arranged in the ascending order of difficulty and six minutes allowed for the test. This time limit was determined empirically, after experimenting upon a dozen or more students at the George Peabody College and some sixty students at the North Georgia Agricultural College.[1] In arriving at the time to be allowed, two considerations were held in mind. It was desired that sufficient time be given for individual scores to cover a considerable range, and thus avoid a large undistributed group of poor records. On the other hand the time should be so planned that a perfect score is impossible. Two individuals with a perfect score might vary in efficiency, but under the conditions of the test no measure of their difference could be obtained.

The test sheets were printed upon a good quality of white paper, eight and a half by eleven inches. The directions printed on the back of the sheet explained to the experimenter as well as to the subject, exactly what was to be done. A copy is included in the Appendix. By mistake the word "rare" was placed between "defective" and stingy." It should follow "aristocratic." In scoring the papers, however, proper credit was assigned the word. The displacement was so slight that it is highly improbable that the final results were at all affected.

Three thousand copies of the test were sent to psychologists in twenty different normal schools, colleges, and universities throughout the country. Of this number, one thousand six hundred and twenty-eight copies were returned for grading from fourteen widely different institutions. Unfortunately, a number of papers arrived too late to be included in the norms herein presented. The table below indicates the number of subjects tested in each school and the class to which both the men and women then belonged.

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[1] These results, which were obtained through the kindness of Professor George Camp, are not included in the norms because the sheets were mimeographed instead of printed.

TABLE XIII

The Number of Men and Women Tested in Each School and Class in Which They Were Enrolled

	Freshmen		Soph's		Juniors		Seniors		Graduates		Total
	Women	Men	Women	Men	Women	Men	Women	Men	Women	Men	
Wellesley College			43		95						138
Brooklyn Training School	148	5									153
University of Illinois	4	2	44	46	60	34	35	16		2	243
University of Montana			23	2	10	5	24	1			66
Alabama State Normal			50								50
University of Chicago	2	6	40	74	7	13	20	9	2		173
Teachers' College					2		13	2	9	28	54
Vanderbilt University						1			1	12	14
University of Kansas		1	32	27	11	6	3	4	1		85
University of Tennessee	1		25	19	7	2	4	2			60
University of Louisiana	2	1	14	9	5	14	8	4	1		58
Fitchburg Normal School	54	17	26		17	2					116
Kansas State Normal	49	6	38	1	15	3					112
Ohio State University	59	63	40	58	33	22	14	13	2	2	306
Total	319	101	375	237	262	102	121	51	16	44	1628

The final results of the sixteen hundred records indicated class variations as well as slight sex differences. In order to ascertain a possible cause, the writer has computed the percentage of students of both sexes in each of the classes. This distribution is shown in the following table.

In grading the papers two classes of errors were encountered, namely, the misspelled word, and the abbreviated word. In the former case full credit was allowed whenever the spelling clearly

TABLE XIV

The Percentage of Students of Both Sexes in Each of the Classes

	Freshmen	Sophomores	Juniors	Seniors	Graduates
Women	.291	.343	.239	.110	.014
Men	.188	.440	.190	.095	.082
Both Sexes	.27	.37	.22	.10	.03

showed that an acceptable word was meant. However, when a word similar in sound was correctly spelled no credit was given. As an example, "save" was not accepted as an opposite of "dangerous," but "richous" (actual case) as an opposite of "sinful" was given full credit. This rule was adopted because without it gradings by different individuals would vary considerably.

Where the response was abbreviated it was given no credit. The only two abbreviations were "opt" as the opposite of pessimistic and "dem" as opposite of aristocratic. In both cases the subject might have intended to write "optimist" and "democrat," both of which would have been scored a failure. Even had he had in mind the adjective instead of the noun, his score would have been raised only five points. No doubt in abbreviating the words, he was thus enabled, at an unfair advantage to others, to write the opposite of a more difficult word. In view of the fact that a time limit was placed on the test, not to penalize abbreviations seems unjust to those students who have followed the directions carefully. Fortunately the number of students abbreviating was negligible.

The sum of the point values of the stimuli as indicated in Table XII is four hundred and thirty-eight. Since each response may receive the assigned value, one-half that value, or zero, almost any score between zero and this number is possible. This wide range of distribution eliminates the probability of a large group of subjects of different ability receiving identical scores. The actual scores based on the records obtained varied from zero to three hundred and fifty-one.

VIII.

THE ESTABLISHMENT OF NORMS FOR COLLEGE STUDENTS

Sixteen hundred and twenty-eight test papers were graded and the norms for college students by the group test were based on these records. In order to ascertain the form of the distribution of the scores made by the several classes, steps of fifty beginning with zero were made and the percent of students included between these steps was estimated. Examination of Table XV reveals the fact that the largest percentage of scores falls between one hundred and one hundred fifty. This is perhaps more clearly shown in the graphs (Figures 2, 3, 4, 5, 6) based on this table.

TABLE XV

Percent of Students of Several Classes Attaining Scores Within the Indicated Limits

Score	Freshmen	Sophomores	Juniors	Seniors	Graduates
0- 49.5	.069	.033	.016	.005	.000
50- 99.5	.356	.272	.190	.184	.066
100-149.5	.397	.346	.318	.406	.300
150-199.5	.124	.225	.247	.214	.250
200-249.5	.045	.078	.156	.111	.163
250-299.5	.007	.032	.063	.047	.133
300-349.5	.002	.014	.010	.028	.086
350-399.5	.000	.000	.000	.005	.000

The norms for college students are presented in the form of percentile tables because this method, statistically simple, admits of convenient use and permits comparisons to be made with other tests, similarly treated. Let us suppose that a directions test has been standardized and the norms compiled in terms of percentiles. Scores made in the opposites test can be compared with scores made in the directions test when both are converted into percentiles. The two percentiles can be averaged or the median computed. This is statistically impossible when the two scores are given in terms of the score in points made on

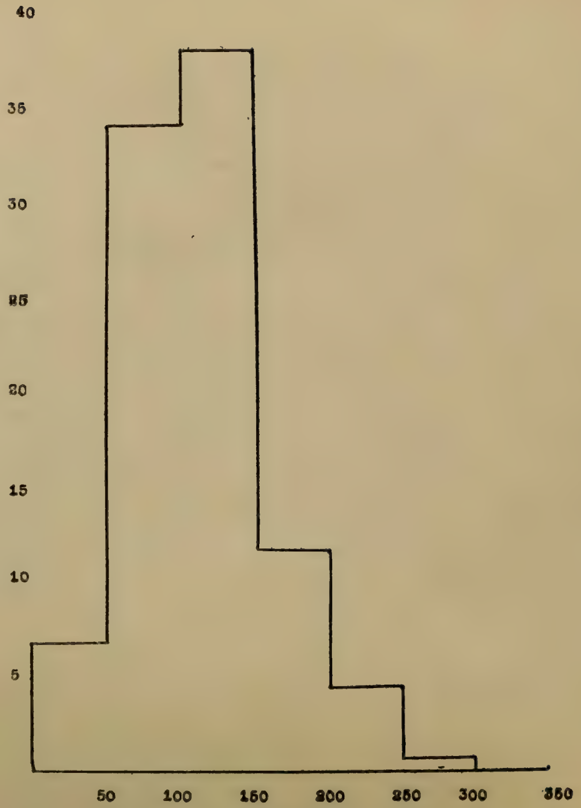

Figure 2

The vertical line of the graph indicates the percentage of freshmen receiving scores shown on the base line.

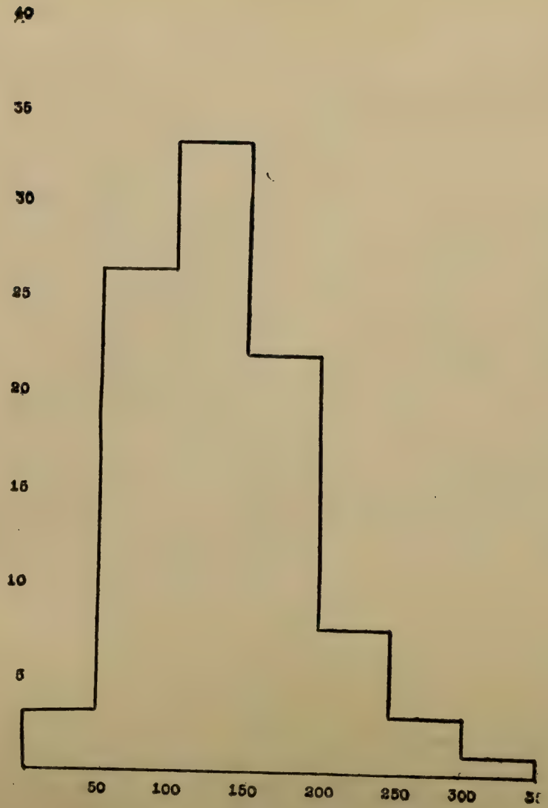

Figure 3

The vertical line shows the percentage of sophomores receiving the scores indicated on the base line.

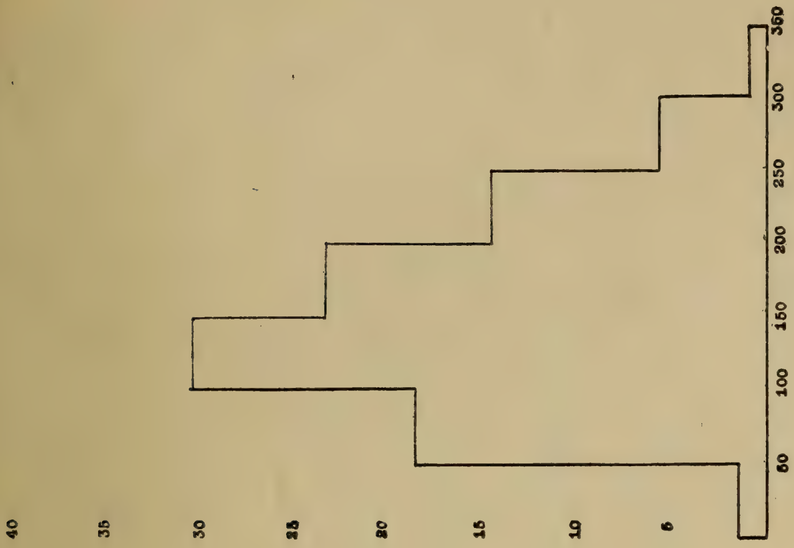

Figure 4
The vertical line of the graph shows the percentage of juniors receiving the scores indicated on the base line.

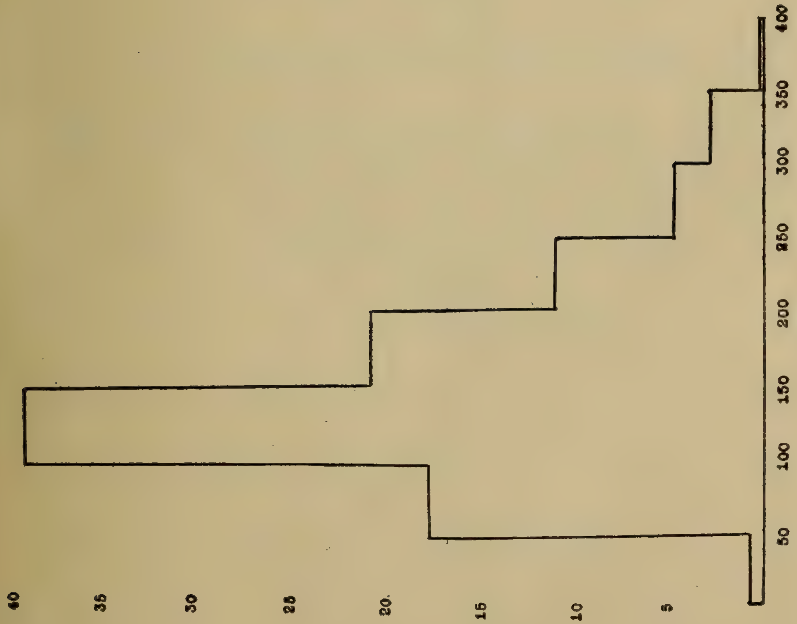

Figure 5
The vertical line in the graph shows the percentage of seniors receiving the scores indicated on the base line.

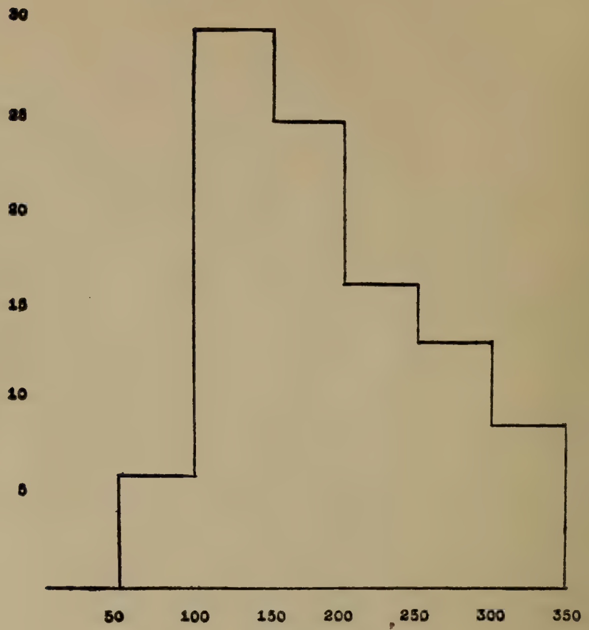

Figure 6
The vertical line in the graph shows the percentage of graduates receiving the scores indicated on the base line.

each test. Obviously, if the possible grades on the opposites test range from zero to four hundred and thirty-eight and on the hypothetical directions test from zero to sixteen, to add or average the two scores made by any individual would practically amount to weighting the opposites test. But the percentile scores can be averaged and the final result will represent a combination of the two tests to which equal credit is given.

In order to make clearer the meaning of the percentile table the following explanation of the manner in which it was derived is offered. For instance in the case of the freshmen, as indicated in Table XVI, all scores were arranged in numerical order, beginning with the lowest and ending with the highest. The number of scores was ascertained, which in this case was four hundred and twenty. Ten percent of the number of scores was counted off, beginning with the lowest score. The score upon which the forty second count fell became the tenth percentile. A glance at the table will show that in this instance it was fifty-eight and a half. This means that this grade is not exceeded by the lowest ten percent of the freshmen, and that any student making this grade is equalled or surpassed by ninety percent of the college students.

An additional ten percent is counted off to secure the next higher percentile, and so on.

TABLE XVI

Norms for College Students in Terms of Percentile Scores in the Group Test

Percentile	Freshmen	Sophomores	Juniors	Seniors	Graduates	All Comb'd
10	58.5	66.5	77.0	84.0	107.0	68.5
20	74.5	84.0	97.0	100.0	124.0	78.0
30	87.0	99.0	116.0	116.5	138.5	101.0
40	97.0	112.0	130.5	125.5	151.0	114.5
50	107.0	125.0	146.0	137.5	155.5	128.5
60	120.0	139.9	161.5	147.0	191.5	142.0
70	132.5	156.0	181.0	166.0	200.0	157.0
80	147.0	178.5	203.0	187.5	247.0	181.5
90	172.0	214.0	239.0	231.0	298.0	220.5
100	303.5	338.0	313.0	351.0	313.0	351.0
Number Tested	420	612	364	172	60	1628

Frequently comparisons of different groups are stated in terms of the percent of individuals of the first group reaching or exceeding the twenty-five or seventy-five percentile of the second group. In the table below the twenty-five, fifty, and seventy-five percentiles are indicated for each class.

TABLE XVII

Twenty-five, Fifty, and Seventy-five Percentile Scores for Each Class

Percentile	Freshmen	Sophomores	Juniors	Seniors	Graduates	All Comb'd
25	82.5	92.5	106.0	108.0	136.0	89.5
50	107.0	125.0	146.0	137.5	155.5	128.5
75	139.0	165.5	192.0	173.0	213.0	169.0

The sophomores surpass the freshmen and they are in turn outstripped by the juniors. The gap between seniors and graduates is wide; but the former are little if at all superior to the juniors. A consideration of the lowest and highest score made by the several classes reveals the fact that although ten percent of the juniors barely reach the lowest score made by the graduates, still the highest score attained by each class is identical. In Table XVIII is shown the gradual rise of the lowest score realized by the different classes, contrasted with the irregularity of the highest score.

TABLE XVIII

Table Showing the Highest and Lowest Score Made by Each Class

	Freshmen	Sophomores	Juniors	Seniors	Graduates
Lowest Score	0	18.5	38.0	46.0	75.0
Highest Score	303.5	338.0	313.0	351.0	313.0

Although men are slightly superior in the test, to women belongs the highest as well as the lowest score. The greatest sex difference is to be found in the fortieth and fiftieth percentiles which in each case are surpassed by the next lowest percentile secured by the men. The table below shows the ten percentiles for both sexes and the number tested in each case. It also includes, for the benefit of those interested in sex differences, the more commonly employed twenty-five and seventy-five percentiles.

TABLE XIX

Percentile Scores for Men and Women

Percentiles	Men	Women
0		
10	72.0	60.0
20	92.5	85.5
25	99.0	92.0
30	106.0	98.5
40	122.5	101.0
50	133.5	115.0
60	147.0	139.0
70	163.5	155.5
75	176.0	167.0
80	189.0	178.0
90	221.0	222.0
100	338.0	351.0
Number Tested	535	1093

A consideration of the range of scores made by both sexes would seem to indicate that women have a wider range than men in the trait in question. Whereas men range only from 18.5 to 338, women beginning with an initial score of 0 reach 351 points as their highest score.

IX.

INTERPRETATION OF THE RESULTS

Whether the test is, as Simpson[1] believes, a selective thinking test, we cannot from the very nature of the data conclude. However, we feel justified in assuming that it is a test success in which is dependent upon native ability rather than number of years schooling. The higher scores attained by the graduates confirm rather than refute the contention, for although there is a constant process of weeding out the mentally inferior, selection operates particularly at the conclusion of work offered for the bachelor's degree. The graphs (figures 2, 3, 4, 5, and 6) reveal a considerable amount of overlapping from year to year. Between ten and twenty percent of the freshmen reach the median score of the graduates and practically thirty percent, the median score of the seniors.

Not without significance is the range of scores of the several classes. An examination of Table XVIII discloses the fact that the highest individual score obtained by either a junior or graduate is surpassed by a sophomore. This condition is not to be attributed to the simplicity of the test, which might admit of a number of nearly perfect records. On the contrary three hundred and fifty-one is the highest score reached, whereas a possible four hundred and thirty-eight could be attained in the allotted time were an individual familiar with the opposites. The lowest score made by the several classes ascends regularly from freshmen to graduates, all of which seems to indicate that instead of the scores progressing in absolute value as the years in school increase, the limit of attainment is about reached in the freshmen year, and thereafter a dropping off of the poorer students raises the percentage of high scores made by the more advanced students.

The form of the distribution of the scores, skewed as it is to the lower end, indicates that the time allotted is too short. Had eight minutes instead of six been allowed for the test, the scores would have been scattered over a wider area and the form of distribution would probably have approached the normal. As it stands the test provides a large number of possible scores which can be attained by the college student. In addition, because of its difficulty, it offers an opportunity of testing a more highly selected group.

---

[1] Simpson, Benjamin R., *Op. cit.*

Sex differences favor the male. King and M'Crory[2] found that the same condition obtained with the hard opposites test they used. In the present investigation twice as many women were tested as men. An equal number might alter the situation. This difference might be due to the fact that the normal schools largely attended by women were slightly inferior in the test to the colleges and universities. In addition, proportionally more women belonged to the freshman class and fewer were enrolled in the graduate school, as is indicated in Table XIV. Until an equal number of unselected cases from each sex is tested, the subject is debatable.

---

[2] King, Irving, and M'Crory, J. L., "Freshmen Tests at the State University of Iowa," *Jour. Educ. Psychol.*, 1918, IX.

X.

SUGGESTIONS AND DIRECTIONS FOR THE USE OF THE OPPOSITES TEST

The following suggestions are recommended for using the test: Distribute the test sheets with the face downward and read aloud the written directions found on the back of the sheets. In timing the class, make use of a stop-watch. Allowing the point value of the word for correct responses and half that value for half correct responses, grade the papers according to the acceptable responses presented in Table X. Add the points and record this sum as the individual's score.

If an entire class is to be compared with the norms herein contained, compute the median score of the class and compare with the fifty percentile to ascertain whether the class is above or below standard. The ratio between the percentile score of the individual or of the class and the fifty percentile of the group may be taken as index of brightness.

Frequently it is necessary to have more than one list of opposites. To meet such a contingency, the list has been divided so that both parts contain an equal number of points and words. The lists are given below, arranged in the order of difficulty. The assigned point value is at the left of the stimulus.

The writer feels that the Opposites Test as a group test has sacrificed to time an important element in that it fails to detect certain aspects of the subject's mind, aspects upon which personal efficiency is so largely dependent. Most significant and enlightening is the attitude of the subject toward the test.

LIST I

1 Full
1 Dim
1 Blunt
1 Pessimistic
2 Public
2 Spend
2 Graceful
3 Ancient
3 Barbarous
3 Despondent
4 Doubtful
4 Busy
4 Abstract
4 Foreign
4 Simple
4 Extravagant
4 Dangerous
5 Defective
5 Reveal
5 Join
7 Permanent
7 Obnoxious
7 Victorious
8 Proficient
8 Rigid
9 Orthodoxy
10 Analytical
11 Loquacious
11 Sacred
12 Spurious
14 Facility
14 Pride
17 Parsimony
22 Suave

LIST II

1	Negative
1	After
1	Success
1	Joy
2	Profit
2	Always
2	Strength
3	Expand
3	Hinder
3	Vague
3	Fertile
4	Injurious
4	Advance
4	Create
4	Aristocratic
4	Rare
5	Slovenly
5	Stingy
5	Diligent
6	Impoverish
7	Elation
7	Sinful
7	Conservative
7	Obscure
8	Repulsion
9	Imaginary
9	Permit
10	Extrinsic
11	Dynamic
12	Heterogeneous
13	Disastrous
15	Result
15	Adroit
26	Exoteric

Whether these attitudes, which Ruger[1] has entitled subjective and objective, so easily perceived by the experimenter, carry over into other lines of work, while highly probable, is a matter that yet remains to be proved.

The poor record in the Opposites Test does not necessarily indicate the subjective attitude but an exceptionally good record does more probably indicate the absence of it. The student becomes easily confused and his attention is divided between the opposite to be given and fear of a bad showing. The score goes low on account of frequent interruptions of which the following are typical: "I know the opposite but I can't think of it right now," "I can't think of the opposite but I know the word perfectly," "This is a vocabulary test and my vocabulary is limited."

This type of subject seldom admits that he is familiar neither with the word nor the opposite. He prefers in the individual test to waste the allotted ten seconds attempting to create the impression that he knows the opposite but this time he can not quite get it. Frequently he forgets the present stimulus in regretting the one just missed.

However if time is wasted in administering the test, it is more than counterbalanced by the speed with which he makes his exit. He does not tarry to ask about some of the words he has failed on, nor is he curious about the records of others. With a hasty explanation of his own inefficiency he hurries from the room, leaving the experimenter with a vague sort of feeling that the latter has purposely inflicted a mortal injury.

In striking contrast is the subject whose interest is centered upon the test itself. He works rapidly offering neither apologies nor explanations. Unashamed he denies knowledge of some of the more difficult words, but rarely does he depart without this knowledge. He is eager to know what others are able to do under the same conditions. Interest in self is overshadowed by interest in the problem in hand.

---

[1] Ruger, H. A., "The Psychology of Efficiency, *Archiv. of Psychol.,* 1910, XV.

Peterson,[2] with his Rational Learning Test, notes these same attitudes, and the writer knows of no better test in which to observe them, for not only are they evident during the administration of the test, but the traits in question can be easily detected in the individual records.

Determination of the extent to which the opposites test reveals native ability, is not attempted in this research. It is hoped that someone will carry on the work here begun, and by a series of correlations empirically determine the scope and limitation of the test. The writer is of the opinion, that if used with other standardized tests, the Opposites Test will be found of value in mental diagnosis.

---

[2] Peterson, Joseph, "Experiments in Rational Learning," *Psychol. Review,* 1918, 25, 462-463.

XI.

SUMMARY AND CONCLUSIONS

I. The Hard Opposites Test herein presented enables the instructor within a brief period to examine a large number of students. Even the most inexperienced will find little difficulty in evaluating the papers, so statistically simple is the test.

II. Initial experimentation began with all words previously employed but eventually the list was narrowed so as to include only fifty-four of these stimuli. Similarly the fourteen original words, for the most part of greater difficulty, were selected from a long list which was subjected to the same process of investigation.

III. Subjects were tested both orally and individually so the experimenter might study each stimulus, from the standpoint of both time and accuracy. Records were kept of each individual response and reaction time. On the basis of these records the relative difficulty of the words was computed. The calculations are based on at least one hundred records for each word, varying up to one hundred and eighty-seven for others.

IV. The acceptable responses were chosen by five judges, from all those responses given by the subjects experimented upon. Additional responses which suggested themselves to each judge were recorded and in turn passed on by the others. Effort was made to have the responses include every possible opposite, not merely the most common ones. These judgments were averaged and a value of 0, ½ or 1 was accorded each response.

V. The relative difficulty of the words was determined by multiplying the median time of all correct and half-correct responses by the percentage of failures, allowing one-half a point for half-correct responses. These values were then converted into standard deviation and steps of 1/5 standard deviation were marked off. Having selected for the easiest word, a word which for college students approached zero difficulty, we assigned to it a value of one, to the next step a value of two. The hardest word in the list received a value of twenty-six.

VI. For convenient use the test was converted into a group test. The stimuli were arranged in the ascending order of difficulty and printed on a good qualtiy of white paper. On the back of the sheet, directions make clear to both the subject and instructor what is to be done. Three thousand copies of the test were mailed to psychologists in normal schools, colleges, and universities throughout the country. From this number the records of 1628 students were obtained, on the basis of which norms for college students were established. These standards are presented in terms of percentiles for each class, including graduates, and for each sex.

VII. The list of stimuli has been divided into an equal number of words and points, for the convenience of any experimenter who may desire two lists rather than one. As it stands, the test can be easily incorporated into a group of tests and comparisons made, provided the other tests are presented in terms of percentiles. The test, because of its large number of possible points and its difficulty, offers an opportunity of testing adequately a less highly selected group than that represented by college students.

VIII. The results of this investigation tend to show that success in the test is dependent upon native ability rather than years of schooling. This conclusion seems justifiable in view of, first, the tremendous amount of overlapping among the several classes, and, second, the gradual rise of the lowest scores from year to year while the highest scores remain constant. The fact that graduates are superior to seniors, and sophomores to freshmen is to a considerable extent to be attributed to the operation of the law of selection.

APPENDIX

Name...
School...
Sex....................................
Underscore the class of which you are a member:
Freshmen; Sophomore; Junior; Senior; Graduate.

Directions for Giving the Test

Before distributing the test blanks, request the students not to turn over the sheets until the signal is given. Ask them to fill in the blank spaces at the top of the page and then make clear what is to be done by reading aloud the following directions:

On the other side of this page are a number of words beside each of which you are to write as quickly as possible the exact opposite. For instance if the word "Black" occurs you should write White." The opposite you write must belong to the same part of speech as the word in the list. Phrases and words formed by prefixing "Non" are counted wrong. Begin at the top and work downward, but in case you do not know the opposites, pass on to the next word, and later, if you have time, come back to those you have omitted.

You will be given just six minutes, so when the Instructor says "Ready" be prepared to write, and when he says "Go" turn over the sheet and begin. Continue until the signal is given to stop.

Full
Negative
After
Dim
Blunt
Success
Pessimistic
Joy
Public
Profit
Spend
Always
Graceful
Strength
Ancient
Expand
Barbarous
Hinder
Despondent
Vague
Fertile
Doubtful
Injurious

Busy
Abstract
Advance
Foreign
Create
Simple
Extravagant
Aristocratic
Rare
Dangerous
Slovenly
Defective
Stingy
Reveal
Diligent
Join
Impoverish
Permanent
Elation
Sinful
Obnoxious
Conservative
Victorious

Obscure
Proficient
Rigid
Repulsion
Imaginary
Permit
Orthodoxy
Analytical
Extrinsic
Sacred
Dynamic
Loquacious
Heterogeneous
Spurious
Disastrous
Facility
Pride
Result
Adroit
Parsimony
Suave
Exoteric

BIBLIOGRAPHY

Bonser, Frederick G., "The Reasoning Ability of Children of the Fourth, Fifth, and Sixth School Grades," *Col. Univ. Cont. Educ.*, 1906, XXXVII.

Bronner, A. F., "A Comparative Study of the Intelligence of Delinquent Girls," *Col. Univ. Cont. Educ.*, 1914, LXVIII.

Greene, Harry A., "A Standardization of Certain Opposites Tests," *Jour. Educ. Psychol.*, 1918, IX, 559-566.

Hering, John P., "Derivation of a Scale to Measure Abilities in Scientific Thinking," *Jour. Educ. Psychol.*, 1919, IX, 417-431.

King, Irving, and Gold, Hugo, "A Tentative Standardization of Certain Opposites Tests," *Jour. Educ. Psychol.*, 1916, VII, 459-482.

King, Irving, and M'Crory, J. L., "Freshman Tests at the State University of Iowa," *Jour. Educ. Psychol.*, 1918, IX, 32-46.

Kitson, H. D., "The Scientific Study of College Students," *Psychol. Monog.*, 1917, XXIII.

Norsworthy, Naomi, "The Psychology of Mentally Deficient Children," New York, Columbia University, 1906.

Peterson, Joseph, "Experiments in Rational Learning," *Psychol. Review*, 1918, XXV, 462-463.

Rosenow, Curt, "The Analysis of Mental Functions," *Psychol. Monog.*, 1917, XXIV.

Ruger, H. A., "The Psychology of Efficiency," *Archiv. of Psychol.*, 1910, XV.

Simpson, B. R., "Correlations of Mental Abilities," *Col. Univ. Cont. Educ.*, 1912, LIII.

Thorndike, E. L., "Mental and Social Measurements," New York, 1916.

Weidensall, Jean, "The Mentality of the Criminal Woman," Baltimore, 1916.

Woodworth, R. S., and Wells, F. L., "Association Tests," *Psychol. Monog.*, 1911, LVII.

Woody, Clifford, "Measurements of Some Achievements in Arithmetic," *Col. Univ. Cont. Educ.*, 1916, LXXX.

Woolley, Helen Thompson, and Fisher, Charlotte Rust, "Mental and Physical Measurements of Working Children," *Psychol. Monog.*, 1914, LXXVII.

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STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF THE UNIVERSITY OF CHICAGO

The Influence of the Time Interval Upon the Rate of Learning in the White Rat

BY
JOSEPH U. YARBROUGH, Ph.D.
Professor of Psychology, Southern Methodist University

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JOS. U. YARBROUGH.

University of Chicago,
Feb. 25, 1920.

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11

I.

Introduction

The experiments reported in this monograph[1] are concerned with three closely related problems in the field of animal psychology: 1) The influence of the time interval upon the rate of learning. The animals were divided into groups, and the terms X and Y were presented in a temporal relation to each group. The comparative number of trials necessary to establish a given strength of functional connection constitutes the measure of the relative efficacy of the several modes of presentation. 2) The readiness with which a given temporal association will function backward, and the most effective time interval for this functioning. The terms X and Y were here presented in the order Y-X, but in the test experiments they were required to function in the normal order X-Y. 3) The claims of the rival thories of simultaneous and successive presentation in relation to the rate of learning. The animals were required to associate two factors, X and Y. To one group the terms were presented simultaneously; to the others, successively.

The nature of the present experiments may be further set forth by additional explanation of the problems under consideration. The various statements made in the modern texts on general psychology indicate that simultaneous or successive presentation is regarded as an essential condition for the formation of an effective association. And by successive is meant *immediate* succession; *i.e.,* the two experiences must be in temporal contact with each other. Our aim is to separate these terms by a certain interval and observe its influence upon the rate of learning the association when the terms are presented in the forward and in the reverse order. Those who hold to the theory of simultaneous association would have us believe that association cannot be formed unless the facts or objects associated be experienced simultaneously. They recognize the fact that in everyday life things are associated which succeed each other in time, but they account for this on the assumption that "with the cessation of the actual mental experience the nervous excitation is not abruptly finished but continues, gradually dying away."[2] The second factor of the association, then, coincides in time with this "gradually-dying-away" nervous excitation of the first, and it is due to this simultaneity that the association of the two factors is formed. The rival theory of successive association, based upon the hypothesis that the range of consciousness is not wide enough to attend to two things at once, denies the possibility of association between two factors simultaneously presented. Those who hold this theory say that although the two factors are apparently presented simultaneously they are in reality successive experiences, since the attention is constantly vacillating between the two. If successive association is correctly explained by the simultaneity of the succeeding experience with the after-phase of the preceding one, the data here presented show to a certain extent the duration of this "akoluthic" phase and its rate of diminution.

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[1] This research was begun in the Psychology Laboratory of The University of Texas in October, 1918, and continued until the following June, at which time the work was transferred to the Psychology Laboratory of The University of Chicago.

Although our prime interest is in the first of the problems listed above, it was found both practical and profitable to gather data on the second and third. Very little work on the main problem has been reported either in the field of animal or of human psychology, hence it is on this point that these experiments will probably have their greatest significance. The second, likewise, has received scanty attention as yet. The third problem, on the other hand, has been the subject of considerable experimentation, although but little of this investigation has been in the field of animal psychology. It is our purpose to present data upon these timely problems, with especial emphasis upon the question of the influence of the time interval in successive association upon the rate of learning in both its backward and its forward directions.

---

[2] Semon, Richard, "Die Mnene," 2te Auflage, Leipzig, 1908.

II.

Historical Section

The purposes of the present historical section are: 1) To bring together for critical consideration all the data reported up to the present time on the rate of learning in successive association; 2) To present a brief critical review of the experimental literature upon the subject of simultaneous and successive presentation in association; 3) To examine all data now published on the strength of function of association in the backward as compared to the forward direction; 4) To show that the evidence is inconclusive because of its scantiness and, in some cases, its general character. Due to the fact that in some of the experiments reviewed more than one of the above-named issues is discussed, it was deemed expedient to present the full report in each case rather than to attempt presentation by topics. Criticism and discussion have in some cases been deferred to the Theoretical Section.

Bigham[3] (1894) was among the first to investigate these questions. For subjects he used five college students of an average age of 24; for material, series of varied numbers and colors (separate or in mixed series) mounted on cardboard 3½ cm. in size. Five simultaneous series were used and five successive. In every respect the series were alike save in the manner of presentation. The length of the series consisted of either 10 or 20 presentations. A 40 second period was allowed for each series, 20 simultaneous presentations being made in this period, and, in the successive series, two seconds being allowed for each of the 20 cards. By this method the exposure time was two seconds, whether the cards were presented simultaneously or in succession. The subjects were asked to use no memory aids in the learning. After a given series had had its due presentation the subject immediately arranged his colors or numbers in the order of the presented series as it was recollected. He saw the series but once. Obviously, only the visible series gave a basis for comparison, and in these Bigham found that for the simultaneous series the percentage of error for the five subjects ran: 13.6, 9.8, 15.3, 17.9, and 15. In the successive series the corresponding percentages of error were 18.5, 23.3, 16.6, 24.1, and 21.6. The averages for the two series were 14.3 percent and 20.8 percent for the simultaneous and the successive, respectively. Hence, he concludes: "With each observer the memory was stronger for the simultaneous than for the successive presentations."

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[3] Bigham, J., *Psychol. Rev.*, 1894, Vol I, pp. 34-38.

Bergstrom[4] (1907) performed a series of experiments patterned after the work of Ebbinghaus. Three subjects were each required to memorize 12 lists of nonsense syllables, 12 syllables to the list, for each of four days. Each syllable was exposed to view for a period of 82σ, and a given time interval was allowed to elapse between the successive exposures of the syllables. The syllables were to be pronounced but once, at the time of exposure, and after four repetitions of a list a recall test was given. In this test a written reproduction was made and the amount memorized was gauged by the number of errors made. The intervals between the exposures were 302σ, 686σ, and 1454σ, and the average number of errors was, respectively, 10.3, 8.9, and 7.5. By increasing the interval between exposures the number of errors was decreased. This fact is at variance with the assumption that a nervous impression begins to fade soon after it is received and gradually dies away, and must be explained by the greater strength either from the clearer original impressions or perhaps by other factors which are favored by a longer time interval.

Again, 30 subjects were used by this same experimenter, and lists of 10 words and lists of 10 letters, presented orally at a metronome-controlled rate, were used as material. The time intervals between presentations here were .5, 1, and 2 seconds. One presentation was made for each list, and the errors made in immediate written reproduction again tested the amount memorized. For the three intervals the average percentages of error were, respectively, 51.12, 36.52, and 23.9 for the word lists, and 44.09, 52.65, and 38.44 for the letter lists. In both, the amount learned increased with the lengthening of the interval. Bergstrom concludes: "The effect of increasing the interval is greatly to decrease the number of errors. . . . Indications are that an interval longer than any employed would have still further reduced the errors."

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[4] Bergstrom, J. A., *Amer. Journ. Psychol.*, Vol. XVIII, pp. 206-238.

Wohlgemuth[5] (1914) reports an experiment the purpose of which, as he states it, is 1) "to decide by experiment, if possible, between the claims of the rival theories of Simultaneous and Successive Association," and 2) "to investigate the influence of the closeness of connection between the members presented simultaneously." He used eight subjects, whose age and qualifications were undefined. To them he gave a series of tests consisting of pairs composed of a colored field (cardboard) followed by a black shape mounted on a white ground, or vice-versa. The exposure was timed by a Müller memory apparatus, a certain definite period of exposure thus being given each card. Obviously, under such conditions the simultaneous pair would have just the same period of exposure as each member of the successive pair. He found the successive mode of presentation superior to the simultaneous, but accounted for the difference on the basis of the unequal exposure time for each pair of stimuli. To overcome this defect two groups were formed: in the first, only half the number of exposures was given in the successive series, while each member of the pair was exposed for the same length of time as the pair of simultaneous stimuli—*i.e.*, the rate of the memory apparatus remained the same; in the second, the same number of exposures was given in both series and the same time given each pair, but only half time was given each member of the successive pairs—*i.e.*, the apparatus was set to work twice as rapidly in the successive series as in the simultaneous. Wohlgemuth finds that in the first group the average scores were 35.5

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[5] Wohlgemuth, A, "Simultaneous and Successive Association," *British Journ. of Psychol.*, VII, 1914-15, pp. 434-452.

for the simultaneous and 33.2 for the successive; in the second group, 36.8 and 34.4, respectively. Hence, he concludes: 1) "The simultaneous experience is more favorable for the learning of pairs than the successive experience." 2) "All associations are due to simultaneity or simultaneity of the succeeding experience with the akoluthic phase of the preceding experience."

On the whole, Wohlgemuth's article is far from convincing. It seems that his evidence is insufficient to warrant such positive statements, and one is inclined to agree with Froeberg[6] in his criticism of the work. Froeberg says that Wohlgemuth's method of presentation must be rejected, but that even if this might be admitted "no safe conclusion could be drawn from the results because the differences in favor of simultaneity are in every case less than the P. E., and in five cases out of sixteen they are negative." Froeberg calls his own investigation an "attempt to repeat Wohlgemuth's experiment with the objectionable features removed." He used psychology students for subjects, and had them memorize series of five pairs of syllables. Each term of the pairs was exposed for a period of 1/3 of a second, and the time between the terms varied from 0 to 5 seconds. The interval between the successive pairs was a constant. The recall came 10 seconds after the last presentation (each series having been presented twice), and was conducted by presenting the stimulus syllables in a new order and requiring the subjects to supply the missing member of the pair. As usual, all memory devices were barred during the learning. The average percentages of correct response for the group of seven subjects were 61, 49, 45, 48, 51, 49, and 49 for the simultaneous and continuous presentations and the intervals of 1, 2, 3, 4, and 5 seconds, respectively—a finding which would indicate that the difference between the simultaneous and successive series is small, and that in successive presentation the length of the time interval is not effective. The simultaneous exposure yielded better results in every case, however, and the average difference of 12 percent in its favor seems significant. Froeberg does not think that this slight superiority of simultaneous presentation necessarily proves the theory of simultaneity, but would explain it by a "tendency to articulate and combine the simultaneous syllables into a single word." From the introspection of his subjects he found "essential agreement on three points: 1) that simultaneous exposure taxes the attention more than successive, 2) that there is a persistent tendency toward articulation in the simultaneous series, and 3) that when in successive association there was an appreciable interval between the stimuli, the first would remain in consciousness, though with varying degrees of intensity, until the second arrived."

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[6] Froeberg, S., *Psychol. Rev.*, 1918, Vol. XXV, pp. 156-163.

In order to eliminate this persisting memory image during the interval between the two stimuli in successive presentation the experiment was repeated with a group of four subjects and with the added condition that the subjects should read numerals presented to them during the intervals between the terms of the pairs, a device calculated to prevent memory survival of the first term during the interval separating it from the second. In this test the average percentages of right response for the simultaneous and continuous presentations and the time intervals from one to five seconds were 54, 45, 34, 36, 40, 24, and 22—*i. e.*, the rate of learning decreased with an increase in the length of the interval when a new activity was interpolated. This decrease in the rate of learning is distinct though irregular. From these data and the statement by each of his subjects that "the reading of the numerals effectively and completely obliterated the memory image of the preceding syllable," he concludes that association may still be formed between two experiences where the first has already passed out of consciousness when the second one appears. This is in contrast with the findings of Bergstrom.

Since Wohlgemuth had rejected nonsense syllables as improper material for the study of association, Froeberg formed another group of subjects to which he presented colors and letters of the alphabet. Other details were the same as in the previous experiments. He found under these conditions that the successive was superior to the simultaneous mode of presentation. This finding in the data of the first group led him to the conclusion that when the material used is such that it forms an organic unit or can be attended as a unit, simultaneous presentation is preferable; when such that this is not possible, successive presentation is the better.

Chamberlain[7] sought to ascertain the effect upon the power of recall when a number of objects were displayed 1) singly and 2) three together. For subjects he used 60 pupils each from the third, fifth and eighth grades. By means of a circular disc of wood certain objects were exposed in fixed order for a given length of time. In the first tests these objects were exposed three at a time; in the second, one at a time. The two modes of display were never used with the same subject. One minute was allowed for the observation of 15 objects. In the first tests each object was exposed for nine seconds, while in the second series three seconds were allowed each object. It is obvious, then, that although one minute was given in both cases for the observation of the fifteen objects, the exposure time per object was unequal. The immediate recall was tested in every instance by having the pupil recall at the close of the experiment all the objects he could remember. These objects were listed by the experimenter in the order recalled. The subjects were also provided with circular sheets of paper and asked to arrange the objects thereon as remembered from the circular disc. The author concludes that both recall and arrangement of objects are stronger when the objects are seen three at a time than when shown singly, a conclusion scarcely warranted by the insignificant percentage of difference between the two modes of presentation. The average number recalled by the three grades when the objects were presented singly was 9; when presented three at a time, 9.37.

In the human field investigations on the direction of association have been made by Ebbinghaus, Müller and Schumann, Müller and Pilzecker, and Wohlgemuth. In each investigation memory material was used. Ebbinghaus[8] employed the relearning method and found a strong tendency for an association to function in the backward direction, but its strength was never equal to that of the forward tendency. Müller and Schumann[9] using practically the same method, confirmed these results. Later, Müller and Pilzecker,[10] using the method of recall, found that when pairs of syllables had been learned as trochees and the first syllable was shown, in 50 percent of the cases the second syllable was reproduced, while when the second syllable was shown the first member of the pair was recalled in only 38 percent of the answers. Here a backward tendency is shown, but it is of less strength than that of the forward direction.

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[7] Chamberlain, A. H., "A Memory Test with School Children," *Psychol. Rev.*, 1915, XXII, 71-76.

Working in the Psychological Laboratory of the University of London Wohlgemuth[11] experimented rather extensively, varying both method and material. He had come to doubt the universal application of the results obtained by the use of nonsense syllables in the study of memory, and to verify the results he used colors and diagrams. To make a further check on his findings he used syllables in exactly the same way as he did colors and diagrams. With five of his subjects the forward tendency was the stronger, and with two the backward and forward tendencies were about equal in strength. He concludes that the forward tendency is the stronger when articulation is used in memorizing, but that the two tendencies are of equal strength when articulation is prevented. Just in proportion as the motor element approaches complete elimination do the results indicate an equal functioning strength in both directions.

In the field of Animal Psychology there is, as we have said before, very little work reported upon the problem. Carr[12] is the chief contributor. He reports a series of brief but suggestive experiments. First, he reports three short experiments, all bearing upon the subject of the influence of the time interval. White rats were used in each of the experiments, and the same problem box. The problem for the rats was to learn to choose between two pathways to a food-box in a given temporal sequence, R, L, R, L, etc. In case of incorrect choice the entrance to the food-box was barred. Always the day's work began with pathway R. Between the successive runs of a day's series the rats were allowed to eat for a definite time interval. In the first experiments three groups of eight rats each were used, and the intervals for the groups were 15, 25, and 35 seconds, respectively. The results indicate no essential differences between the groups in the initial stages of the learning, and, indeed, no essential differences throughout for the 15 and 35 second intervals. The group tested on 25 seconds interval manifested a quite rapid rise from the 1000th to the 1200th trial. This, however, is an inconclusive finding, as other factors than the time interval may have influenced the result. The group was too depleted, unfortunately, to permit of further continuation of the experiment. In a second experiment three groups, six rats each, were tested for intervals of 5, 10, and 15 seconds, respectively. In this test the entrances to the pathways R and L were alternately blocked so that errors were impossible. Test series in which the pathways were left open were interpolated every fifth day. Thus the rats were forced to choose between the pathways and the learning was measured by the number of correct choices made in these test series. To quote the results: "The group difference is not very significant, but the results indicate that 10 seconds is a more favorable interval than 15 seconds." In brief, he admits that his findings are inconclusive as regards the influence of the time interval upon learning, but states that they do prove that "an association nexus can be established over a considerable interval of time," and that they make possible the acceptance of the hypothesis of direct connection between the factors in successive association.

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[8] Ebbinghaus, "Über das Gedächtniss," Leipzig, 1885.

[9] Müller and Schumann, Experimentelle Beiträge zur Untersuchung des Gedächtnisses," *Ztsch. f. Psychol. u. Physiol. Sinnesory*, 1894, VI.

[10] Müller, C. E., and Pilzecker, A., "Experimentelle Beiträge zur Lehre von Gedächtniss," *Ztsch. f. Psychol.*, 1900, Ergänzungsbd. 1.

[11] Wohlgemuth, A., "On Memory and the Direction of Association," *Brit. Journ. of Psychol.*, 1912, Vol. V, p. 447.

[12] Carr, H. A., "Length of Time Interval in Successive Association," *Psychol. Rev.*, Vol. XXVI, pp. 335-353.

Carr and Freeman[13] report an experiment upon the problem of simultaneity vs. succession, and upon backward vs. forward direction in forming an association. A box with zigzag runways was used. In preliminary tests rats were taught to run these pathways in order to obtain food. Afterwards in 80 per cent of the trials the door from the chosen pathway into the food-box was closed, and the rats were forced to retrace and run the opposite pathway in order to reach food. At this stage the rats were divided into three groups for the purpose of testing the formation of an association between an auditory stimulus, buzzer, and the act of turning in response to the closed door. With one group the buzzer was sounded just as the rat was in the act of turning—simultaneously with the response to the closed door. With another the sound was given at a definite point, P, approximately one second before the door was reached. The third group was given the sound at point P in the return pathway approximately one second after the rat had turned around from the closed door. Test series wherein the sound was given at any point within the pathway were used to test the formation of the association. It was found that "successive presentation of the two terms constitutes a much more favorable method for their association than does simultaneous presentation." The groups on backward association showed slight evidence of learning when the experiment closed. These results are extremely suggestive, but some points of weakness should be pointed out: 1) The time interval between the two terms to be associated was not constant. Those who are acquainted with the behavior of white rats would not expect them to traverse the distance from a point, P, to the closed door at the same speed each time. 2) The buzzer which was the source of the sound stimulus was in contact with the maze. The animal may, therefore, have been responding to a kinaesthetic or cutaneous sensation and not to sound at all.

Watson's experiments also contribute data in the comparative field bearing upon this problem of backward association. He tested white rats for their ability to learn a maze backward after having learned it in the forward direction. These data are not considered conclusive, for all who have trained rats know that considerable retracing is done while mastering a maze.

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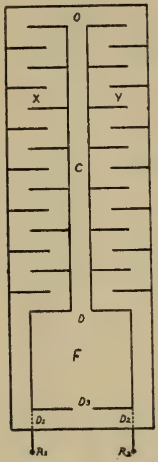
[13] Carr, H. A., and Freeman, A. S., "Time Relationships in the Formation of Association," *Psychol. Rev.*, Vol. XXVI, p. 465.

Summary. 1) The majority of the experimental data reviewed favors the simultaneous mode of presentation. 2) In regard to the time interval, Bergstrom is convinced that with the increase in the length of the unfilled time interval the amount learned increases. Froeberg is of the opinion that an increase in the length of the time interval increases the difficulty. 3) All investigators have found a tendency toward backward association—a tendency varying in strength, but seldom equal to and never stronger than the forward tendency.

III.

Apparatus and Method

The ground plan of the problem box used in this experiment is shown in Fig. 1. The outside dimensions are 89″ x 30″. The box is constructed of ¼″ soft pine, and is 6″ deep. All runways and doors are 4″ wide and 5″ deep. The doors are made of very thin metal and are so hung that they may be opened and closed without appreciable noise. Especially is this true of doors D1 and D2 which are controlled by rods R and R1. The entire surface of the box is painted black. The food-box F is 16″ x 20″ and is the only portion of the box not covered with glass. The entire floor of the maze in front of the food compartment, with the exception of the long runway from the center door D, to the point O, is laid with No. 20 copper wire at ¼″ intervals. By pressing a contact key a current from three dry cells is sent through an induction coil which sends an induced current over the entire system of wire on the floor of the maze. The strength



Ground Plan of Apparatus

Fig. 1

of the current passed over these wires is so controlled that the animal never becomes frightened by a severe shock.

This box was developed from the one used by Carr and Freeman[1] in their experiments. The following improvements were made in the construction of the present box: 1) The glass cover was extended so that the animal is not required to come out in the open until it enters the food-box. 2) There is but one door to the food-box. 3) The source of the stimuli is above the glass cover, making contact with the animal impossible. Furthermore, it was necessary to increase the box in length and number of compartments to secure sufficient time between the point of choice and the food-box for the presentation of the two stimuli with an interval of six seconds between them. The animals seldom made the distance in so short a time, but in their most rapid responses the entire distance was traversed. The additional apparatus used in presenting the pair of stimuli in certain temporal relations are rather tediously described below.

About 18″ above the center of the box a light of very low candle power is suspended. The light from this source is just sufficient to enable the experimenter to see the animal move through the maze. Similarly, an electric buzzer is suspended 10″ above the glass cover of the middle portion of the box and connected with the batteries and the timing apparatus as is indicated in Fig. 2. The timing apparatus is, in turn, attached to a Zimmerman kymograph by screws E and E[1] in a way shown very well in Fig. 3.. The revolving disc upon which the arm A rests is in direct connection with the shaft of the kymograph, which turns it around the dial at any speed desired. The dial is graduated so as to read seconds, half seconds, and quarter seconds, when the kymograph is adjusted at the rate of one revolution for every 15 seconds. Each of the numerals, therefore, represents the number of seconds necessary for the arm A to move from the zero point to the respective numeral as it appears on the dial. The contact B may be moved along the dial and firmly set at any point by the thumb screw. The arm A is not

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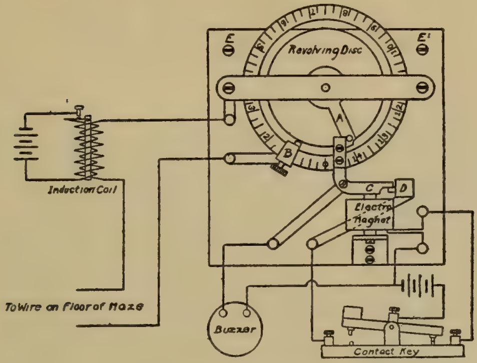
[1] Carr, H. A., and Freeman, A. S., "Time Relationships of Association," *Psychol. Rev.*, Vol. XXVI, p. 465.



Timing Apparatus

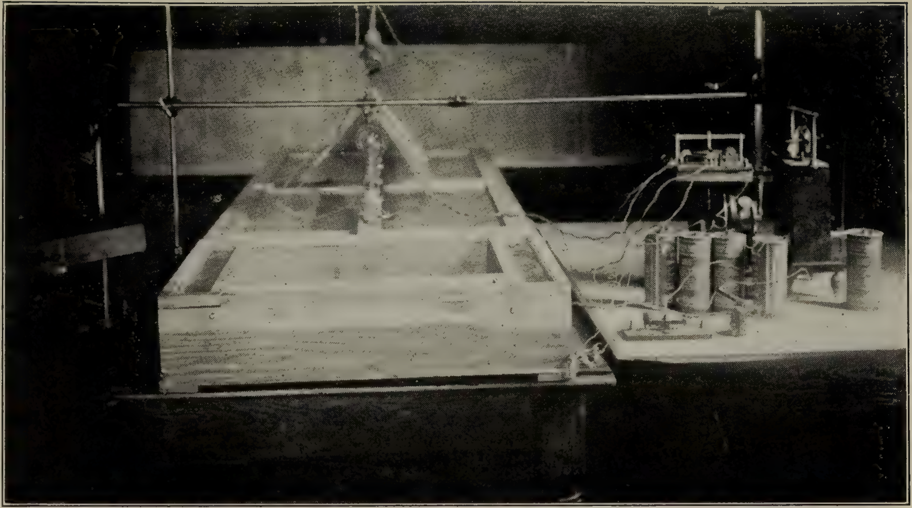
Fig. 2

fastened to the shaft of the kymograph, but is carried along by friction on the large revolving disc. If the circuit is closed and the electro-magnet pulls the lever C into place, the arm A is held in the position shown in the drawing. The strength of the magnet is great enough to overcome the friction on the revolving disc.

By pressing the contact key the circuit of the electro-magnet is broken, and is closed on the electric buzzer. This presssure not only gives the sound stimulus, but it also releases lever C, allowing arm A to be carried along with the revolving disc and to pass over contact B, which closes the circuit through the induction coil and the system of wires on the floor of the box. When the contact key is released the current again flows through the electro-magnet, attracting lever C, which keeps the arm A from moving when it again reaches that point. Thus the apparatus automatically completes the process, and after 15 seconds it stands ready for a repetition at the will of the experimenter. The friction contacts at D and B are so constructed that the current is broken at the end of one-half second. Each stimulus is, therefore, given for this period of time. By this apparatus it is possible very accurately to present two stimuli in a certain definite temporal relation to each other.

With certain groups of animals light was used as one of the two terms to be associated. The new apparatus added for presenting the light may be seen in Fig. 3. Directly above the long central runway and in contact with the frame of the glass cover of the box a piece of soft pine 1″ x 2″ - 4′ is attached, and to it is affixed two lamps connected in parallel. The first lamp is 18″ from the end of the box; the second is 22″ nearer the food-box. National Mazda 100 Watt lamps are connected on a 115 Volt circuit. In order to direct the light upon the zigzag pathways a reflector is suspended directly over the lights and so adjusted that the light falls on these runways only. With proper electric connections the timing apparatus enables us to present sound and light in a certain known temporal relation, just as the buzzer and pain were previously presented.

The method of procedure may be described as follows: The animal to be tested is put through the door D from the food-box F into the central runway C. He is required to go up to point O and turn either to the left or to the right and return through the zigzag pathway X or Y, through the door D1 or D2, and through D3 into the food-box F where he is given food. It is of little interest in these experiments whether the animal turns to the one side or the other, or to one side altogether, for the problem is in no way affected by the alley chosen or by position habit. The alley chosen in no way determines what is to follow. Seven times out of ten trials the animal is given an electric shock in the return zigzag runway; no shock is given in the three remaining trials. This shock may be given at any point along the runway, lasts for a period of one-half second, and is given only once during the trial. The problem here is to learn to turn around for pain or to go on in case no pain is given. If pain is given and the animal does not turn around but goes on toward the food-box he finds the door at the end of the alley closed. Thus, for example, if the door is D2 he must, to gain entrance to the food box, run back through the zigzag alley Y, pass the point O, and approach through the alley X and the door D1. When no pain is given the door of the alley selected is always open and the animal enters the food-box direct. The problem here may, therefore, be thought of as an association



Perspective of Apparatus

Fig. 3

between a closed door and an electric shock, and farther on in this report it will often be referred to as learning the negative response to pain.

From the above conditions it will be noted that no stimuli are given in 30 per cent of each series of trials. This, together with the fact that chance and position habits are of so little significance in the solution of the problem, led us to hold a rather rigid standard as to the number of trials and the percentage of correct reactions to be required of all animals. No animal was, therefore, considered to have mastered the problem until he had made 90 per cent correct responses on the last 100 trials. All animals used in the experiments reported below were first required to learn this negative response to pain. When this was accomplished an electric buzzer was introduced, by means of the timing apparatus, in a certain definite temporal relation to the electric shock, pain. The animals were divided into groups and each group was set to work upon the problem of transferring this negative response from pain over to buzzer, but each group worked with a different time interval. To some groups the stimuli (buzzer and pain) were presented in a forward direction; to others, in a backward—*i.e.,* some groups received the buzzer followed by pain, others, pain followed by buzzer. In the test series the order was always buzzer followed by pain. The problem in each group is to learn to respond to the sound stimulus as they have been responding to pain. It is a transfer of response from pain to sound over certain given time intervals. Continuous presentations and one, two, four, and six second intervals were studied. In the work with the first of the above groups special test series of 10 trials each were given after each 20 trials to determine to what extent the transfer had been made. In the remaining groups the time interval was sufficiently large to determine this without these special tests. The standard for mastery in each of these groups is the same as before, 90 per cent on the last 100 trials.

As the animals completed this problem they were regrouped and set to work on a third problem, but in the regrouping no animal was changed from a group where the stimuli were presented in the backward to a group where they were presented in the forward direction or vice versa. The situation really remained the same with the exception of the changed stimuli—*i.e.*, the substitution of the response is now from the auditory stimulus to light instead of from pain to sound as before. The same time intervals were studied as before. As in the previous experiment, it was necessary to enter the special series of test trials only in the study of the first interval to determine the extent to which the transfer had been made at any given time. The same standard is required here as in other problems.

IV.

EXPERIMENTAL RESULTS

1. *The Influence of the Time Interval in Successive Association upon the Rate of Learning.*—The experiments bearing directly upon this problem may be divided into two sets: A. Those in which the association was learned in the forward direction; B. Those in which the association was learned in the backward direction. Groups I to XII were tested in the first set and Groups XIII and XIV in the second. All the animals were of about the same age and health conditions. Twenty trials were given each day. To have mastered the problem the animal must have made not less than 90 per cent of correct responses over a period of five consecutive days, *i.e.,* 90 per cent on the last 100 trials.

A. Learning the Association in the Forward Direction.—Associations were made between stimuli from different sense fields. Two pairs of stimuli were used: a) auditory (buzzer) and pain (electric shock), and b) visual (light) and auditory. The auditory-pain experiments are presented first.

a) Association of buzzer with electric shock.—In order to secure comparative data upon the influence of the time interval between the presentation of buzzer and the presentation of pain, the animals, upon mastering the problem of negative response to pain,[1] were divided into groups, and each group was set to work to transfer this negative response from pain over to the buzzer. The sound was always presented before pain but in a different temporal relation to pain in each of the groups. Other factors remained constant for all of the groups. In addition to presenting the stimuli in immediate succession, *i.e.,* in temporal contact, presentations at intervals of one, two, four, and six seconds were made. In all, 38 animals were used.

1) Continuous presentation.—Group II was trained on buzzer followed by the pain immediately. The results of the work of this group are summarized in Table II.

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[1] See division 3 of this section.

TABLE II

Animal	Trials	% Correct on Last 100
25	120	91
26	120	90
27	140	92
28	120	91
29	120	90
50	100	93
Average	120	91.1

A set of test trials was interpolated after each 20 trials of the regular series in order to measure the gradual growth of the association. The average number of trials necessary to master this problem was 120, but a study of the curve in Fig. 4 and the records of the individuals of the group show that after 60 trials some of the group held their record to and above the 90 per cent mark, and that after 80 trials no animal fell below this point.

2) One-second Interval.—Group III was used in these tests. The buzzer was presented one second before pain, to which they had previously learned to respond negatively. If the old response to pain was transferred to the sound stimulus, and the animals turned around for it, no pain was given. But if they failed to turn around to the buzzer and instead continued toward the food-box, the pain was given at the end of one second. Results are given in Table III. It was unnecessary to give the special test series in this group in order to determine the gradual growth of the association, for if, in the regular training series, the animals failed to turn around before pain was given, the response was recorded an error: if they turned at the sound no

TABLE III

Animal	Trials	% on Last 100
1	118	96
12	131	91
22	128	91
24	126	92
35	148	90
37	120	87
Average	128.5	91.1

pain was given. These regular tests, therefore, show the gradual growth of the association if properly analyzed. The analysis of Table III is given in the curve presented in Fig. 4. Each point of this curve was determined by the average per cent of correct responses for the group in 20 trials of the regular training series. The growth of the association, as determined by the percentage of correct responses, is recorded for each 20 trials during the entire learning period.

The 30 per cent of trials in which no stimuli were given proved to be an excellent control for determining whether or not the animals had developed the habit of turning each time in the first alley selected, or were turning only when the sound was encountered. Without an exception they continued to the food-box during these trials. Very often they would proceed slowly and manifest hesitancy, much as the human does during a period of expectancy and uncertainty, but in no case did they turn around. The following conclusion is warranted: The turning response was transferred *from* pain *to* buzzer rather than to some other factor; 128.5 trials were necessary to perfect this transfer.

3) Two-second interval.—The two stimuli were presented to Group IV with an interval of two seconds. Again the special tests were omitted and the rate of of learning measured in the regular trials. Tabulated results for the group are to be found in Table IV. With the exception of Nos. 10 and 39 the individual differences are small. With No. 10 the association began early in the period, but it was very difficult for him to hold the percentage of correct response over a period of five days. Num-

TABLE IV

Animal	Trials	% on Last 100
10	316	92
11	210	91
21	166	92
23	211	90
38	203	93
39	269	90
Average	229	91.2

ber 39 was very slow in beginning the transfer, but when once started the percentage increased normally.

The gradual growth of the association in this group is obvious from the curve in Fig. 4. Each point of this curve represents the average for the group in percentage of correct response for 20 trials of the regular learning series. Although we had used the 30 per cent of undisturbed trials throughout these experiments, at the end of the work each animal was given a special series of ten test trials in which pain was withheld. In these tests the response was unaffected. The group required an average of 229 trials to reach the standard imposed.

4) Four-second Interval.—With Group V the sound was presented four seconds before pain. Seven animals were used in the group, and Table V gives their data. There are no marked individual differences, a gradual increase in correct responses being maintained by each animal, as is graphically shown in the learning curve in Fig. 5.

TABLE V

Animal	Trials	% on Last 100
4	236	94
13	265	92
16	240	91
19	187	91
40	228	93
41	216	94
52	269	91
Average	236	92.4

After the work was completed the special set of test trials was given with no effect upon the per cent of correct responses. The average number of trials necessary for mastery was 236.

5) Six-second Interval.—Group VI made the association over an interval of six seconds. Table VI shows the number of trials necessary to make the association and the standard of correct reaction reached. From the table and the learning curve in Fig. 5 it is possible to appreciate the general disturbance during the first 60 to 100 trials, as well as the gradual growth of the association. During this first period of learning the animals not only

ignored the buzzer, but also the negative response to pain often broke down.

TABLE VI

Animal	Trials	% on Last 100
43	229	92
45	226	91
46	217	91
47	224	90
48	274	90
49	280	93
51	288	89
Average	248.3	90.9

In other words, if the animal failed to turn for the buzzer he also often failed to turn for the pain and continued his course toward the food-box until he encountered the closed door. This same thing happened in all the groups but not so frequently as in this one. This common period of confusion prehaps accounts for the larger number of trials necessary for this group to master the association.

Summary.—The results for these five groups are brought together in Table VII. From these results the following conclusions are warranted: 1. Measured in terms of the number of trials necessary to learn the association, the difficulty of making the transfer of response does not increase uniformly for the increase in the length of the time interval between the two stimuli presented. 2. There is a disproportionate increase in difficulty when the interval is increased from one to two seconds. 3. There is practically no increase in difficulty when the interval

TABLE VII

Group	Time Interval	Trials
II	0 seconds	120
III	1 "	128.5
IV	2 "	229
V	4 "	236
VI	6 "	248.3
	Average	192.3

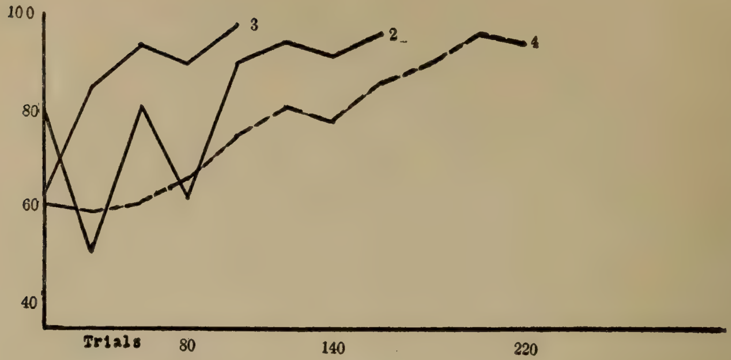


Figure 4

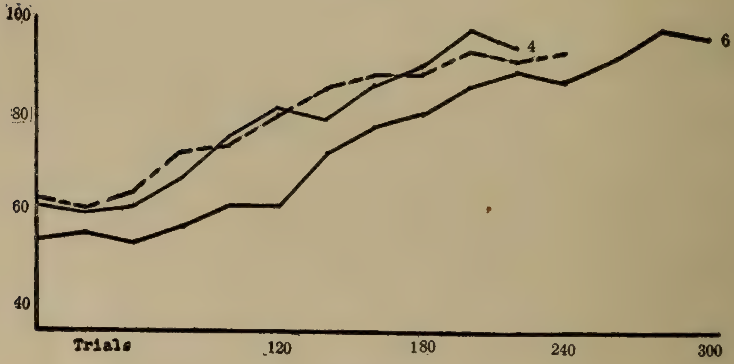


Figure 5

Curves 2, 3 and 4 (Fig. 4) are the learning curves for the Groups II, III and IV, respectively. Curves 4, 5 and 6 (Fig. 5) are the learning curves for Groups IV, V, and VI.

is increased from two to four seconds. 4. The six-second interval is more difficult than the four-second, but the increase in difficulty is not so great as from the one-second to the two-second interval.

b) Association of Light with Sound.—When the animal had made the association of sound with pain, the pain had in reality dropped out, and the animal responded to the buzzer whenever presented. To demonstrate the accuracy of this statement a special set of test trials was given at the end of the learning period in which pain was not given at all, and the percentage of correct response was not affected. It was possible, therefore, to introduce another stimulus affecting still another sense at certain definite time intervals before the buzzer, just as the buzzer had been entered before pain in the groups previously reported. Light was selected for this new stimulus. By properly connecting the timing apparatus in the light circuit as described above, it was possible to present the two stimuli (sound and light) with a known time interval between them. The animals were regrouped and five new groups were set to work on learning to transfer their motor response from sound over to light. With the exception of the time interval, conditions were constant for all the groups. As before, experiments were made with continuous presentation and with one, two, four, and six second intervals. The 90 per cent standard was again adopted. In all, 24 animals were used on this problem.

1) Continuous presentation.—Here the problem was the association of light with sound when presented in immediate succession. The data for this group are given in Table VIII. One hundred trials were given to each animal, but the test trials show that the association was complete at the end of 60 trials. The curve in Fig. 6 shows a period of fluctuation in correct response between the regular series and the test trials. After 60 trials in the regular series the curve remains almost uniform at 90 and above. This uniformity was reached in Group II at the end of 40 trials. A comparison of this curve with that of Group II, Fig. 4, indicates that the light and the buzzer offered a problem of practically equal difficulty with the sound-pain association in the first part of the period, but the transfer to light was more readily made. From a study of the individual records in the two groups it was found that under these conditions when ani-

TABLE VIII

Animal	Trials	% on Last 100
48	100	96
49	100	89
50	100	91
51	100	90
Average	100	91.5

mals once learn to respond to light they hold a more uniformly high record than when responding to sound. On the basis of the number of trials necessary to make the association it was easier for the animals to associate light with sound than sound with pain, when the two stimuli were presented continuously.

2) One-second interval.—The animals in Group IX made the light-buzzer association over a one-second interval. They had just transferred the negative response from pain to buzzer, and the new problem called for this response to be transferred to light, the latter being presented one second before the former. When the animal turned to the light, the buzzer was not sounded. Failure to respond negatively to light was recorded an error. Table IX gives the data for this group. No special test trials were given, the results of the regular training series being sufficient to show the rate of learning the association. The percentage is very low at the beginning of the learning period and increases rapidly, giving a positive accelerating curve. When compared with the learning curve for Group III, where all conditions are the same except the stimuli, two marked differences are found: 1) The percentage of correct response in the first 20 trials is considerably lower for Group IX; 2) no learning is indicated by Group IX until after 40 trials, while learning appears to have begun immediately with the other group. Under these conditions, 145 trials were necessary to transfer the negative response from the sound to the light.

TABLE IX

Animal	Trials	% on Last 100
37	160	94
45	140	92
46	140	94
47	140	93
Average	145	93.2

3) Two-second interval.—To Group X the stimuli were presented with an interval of two seconds between them. The animals dropped low in efficiency in the first series, but when learning began the curve rose as rapidly as that for Group IX.

See data in Table X and the learning curve in Fig. 6. The problem for Group X differed from that for Group IV only in the matter of stimuli used, but there is a marked difference between the curves for the two groups. In the Group IV curve is shown a period of no learning, followed by a brief plateau and a second period of gradual growth, which brings the record up to the standard. In contrast, the Group X curve shows a shorter period of no learning, followed by rapid progress. There are two possible explanations for this dissimilarity. First, it may be due to the previous training the animals in Group X had had in the problem of pain-sound transfer. Second, the pain-sound transfer may be more difficult than the sound-light transfer.

TABLE X

Animal		Trials	% on Last 100
13		160	93
16		180	90
19		160	92
35		180	93
	Average	170	92

4) Four-second Interval.—The animals in Group XI were trained to associate light with the buzzer when presented with a time interval of four seconds. Table XI records the results.

TABLE XI

Animal		Trials	% on Last 100
4		160	92
23		140	93
38		160	91
39		160	90
	Average	155	91.5

From these data and the curve in Fig. 7 one may see the rate of learning the association and the number of trials necessary to master the problem. There are no marked differences between the data of this group and those of Group X above. In each case there is a complete breakdown in the early part of the period followed by a period of rapid learning. With this group there

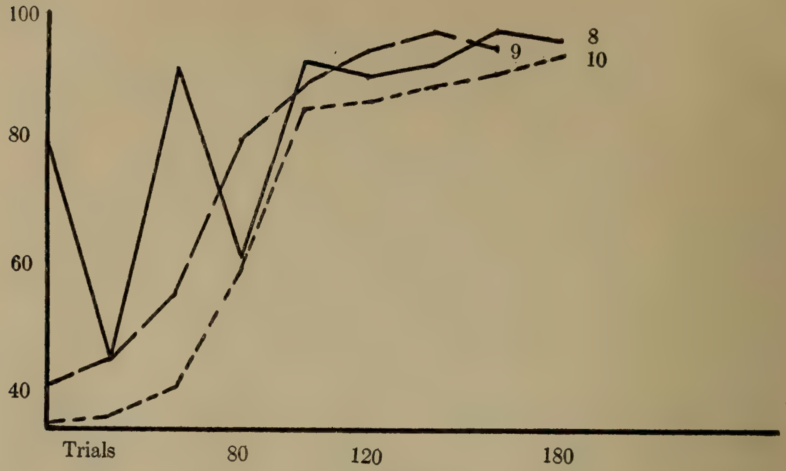


Figure 6

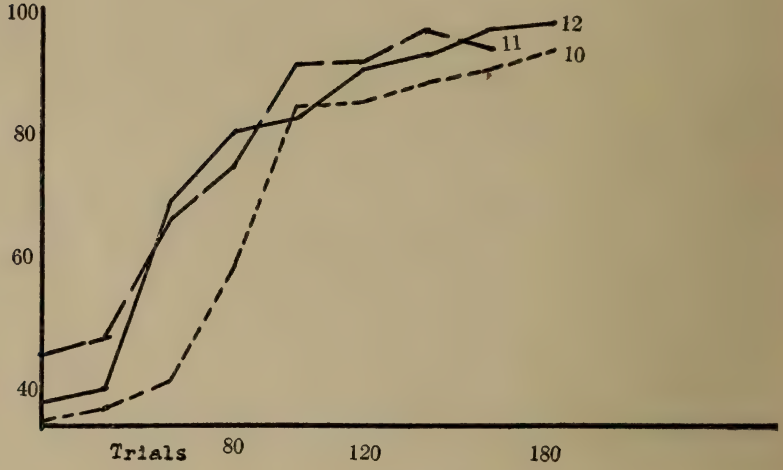


Figure 7

Curves 8, 9, and 10 (Fig. 6) are the learning curves for Groups VIII, IX, and X, respectively. Curves 10, 11 and 12 (Fig. 7) are the curves for Groups, X, XI and XII.

appears to be no increase in difficulty with an increase of the time interval from two to four seconds. But when compared with the data of Group V in which sound and pain were presented in the same temporal relation, two points of difference appear. First, the breakdown in the beginning of the learning period is more marked in the latter. A percentage of 45 was made in this group, while in Group V an efficiency of 62 per cent was maintained. Second, the learning curve rises much more rapidly for Group XI. The percentage of increase rose from 45 to 95 in four series of trials, while in Group V the increase for the corresponding period was from 67 to 74 per cent. Seven days were required for Group XI to reach the 90 per cent mark of correct response. Previous training is an explanatory factor, but indications are that this difference is largely due to difference in the stimuli used. The data thus far gathered indicate that, other things being equal, it is more difficult for white rats of the type used in these experiments to associate sound with pain than light with sound.

5) Six-second Interval.—Group XII learned the association when light was presented six seconds before sound. In Table XII is given the data for this group. The association over this time interval required more trials than did that for any other group, but the difference is not great enough to be of significance. The curve in Fig. 7 will assist in showing the rate of learning. In form it follows rather closely the curve for Group XI—low at first, followed by a period of rapid learning.

TABLE XII

Animal	Trials	% on Last 100
1	160	91
10	200	94
11	180	92
12	180	95
Average	180	92.5

The effect of stimulus difference is shown by comparing this curve with that of Group VI. The curve for the former group begins somewhat higher, and instead of rising higher it first tends downward and later ascends, gradually reaching the 90 per cent mark after 180 trials; the curve for the latter exhibits a very brief period of no learning, followed by very rapid progress.

Summary: To enable the reader to see at a glance the results obtained in each of these five groups the following table was constructed. From these data and the curves presented the following conclusions were reached: Judged on the basis of the number of trials necessary to make the association, the difficulty of the problem of transfer of response from light to sound appears not to have increased proportionately with the increase in time interval between the presentation of the two stimuli. Practically the same increase in difficulty is manifest in going from continuous presentation to the one-second interval as in going from the one to the two-second interval. The four-second interval, on the other hand, seems easier to master than the two-second but less easy than the one-second. The learning curves start low, go through a short period of no learning, and then rise rapidly in each group.

TABLE XIII

Group	Time Interval	Trials
VIII	0 seconds	100
IX	1 "	145
X	2 "	170
XI	4 "	155
XII	6 "	180
	Average	150

B. Learning the Association in the Backward Direction.—In reading the literature on the phenomena of association one is lead to the belief that psychologists generally hold to the conclusion that recall is predominantly in the forward direction. Some experimental data, however, indicate that an association will function backward as well as forward. Freeman found that "the formation of an association between a stimulus and a motor response by animals is exceedingly difficult and perhaps impossible when the stimulus is presented after the act has occurred." Since our method of procedure and experimental conditions were so different it was decided to include an examination of this point.

Two groups of animals (Groups XIII and XIV) were used in these experiments, the problem being the transfer of the previously learned negative response from pain over to the auditory stimulus (electric buzzer). The buzzer was given in each case after the pain had been given: to Group XIII it was presented in immediate succession; to Group XIV, with an interval of one second separating it from pain. Thus, in the latter case the two factors were presented in the backward order with a time interval of one second between them, *i.e.,* the sound stimulus was presented after the motor response to pain had been initiated and in some cases completed. All the animals were given, in addition to the regular training series, a series of test trials. The object of the training series was to establish an effective association between the turning response to pain and the auditory stimulus; the object of the test trials was to determine the degree to which an effective association had been formed. In these tests the procedure was the same as in the training series except that no pain was given. If the negative response had been transferred to the auditory stimulus, they should turn and retrace the path when the buzzer was sounded. A correct response consisted of an immediate turn when the auditory stimulus was presented, or of traversing the whole length of the path into the food-box in the 30 per cent of trials in which no stimulus was given. Progress was measured by the increasing percentage of correct response during the test trials. For in each group the established negative response to pain prevented the animals from responding to sound during the training series. They would most often have turned around or be turning around when the auditory stimulus was given. It is obvious, therefore, that the new stimulus which was to be associated with the turning response occurred after the act of turning had been initiated. A correct response in the regular training series is the same as it was before the auditory stimulus was introduced, *i.e.,* an immediate turn when the pain stimulus was presented, or traversing the whole length of the path into the food-box in the 30 per cent of trials in which no stimulus was given.

The number of animals used, the number of training trials necessary to make the association, and the percentage of correct responses for Group XIII are given in Table XIV. In the test series only one term of the pair to be associated was presented. These trials would, therefore, not be added to the regular training series in order to secure the number of trials necessary to make the association. Their effect would really be expected to hinder the rate of learning, since each time they took the place of a regular day's work, thus making a break in the regular training series. Since each animal completed his work on the test series, the percentage of right response on the last 100 trials, presented in the last column on the table, includes four series (40) of test trials and three (60) of trainnig trials. It was planned to use only the test trials as a basis for this percentage, but since each animal had held a percentage of 90 or above for a period of seven days we were satisfied that the transfer of response was completely made.

TABLE XIV

Rat		Training Trials	Test Trials	% on Last 100
53		140	60	90
54		120	50	92.5
55		140	60	94
56		120	50	91
	Average	130	55	91.8

From Graph 13 in Fig. 8 the rate at which the association was made can easily be observed. The values in this curve represent the percentages of correct response in the test trials given at the end of the first 40 trials and following each series of 20 trials thereafter. The test series was not introduced in these groups until after the first 40 trials, because it was assumed that not until after then would the transfer of response be sufficiently made to make it worth while to interrupt the regular training series. Since the correct response in the 30 per cent of trials in which no stimulus was given had become thorougly learned in the previous training, mistakes in these trials seldom occurred. Consequently, the percentage records of this group may be expected to begin at 30 and increase to 90 and above as the motor response is transferred to the auditory stimulus. Since the test trials interpolated after the first 40 training trials show 79 per cent of correct response, it is safe to infer that considerable transfer was made during these 40 trials. The association was readily made; with, in fact, but little more difficulty than was experienced when the two stimuli were presented continuously in the forward direction. This small difference may be due to chance or to the fact that a smaller group was used in these last experiments.

When the animals of Group XIII had learned the association of negative motor response to sound, light was presented in the same temporal relation to sound as sound had been to pain in the previous training, *i.e.,* in immediate succession. By this means it was hoped to get some data on the relative merit of the different stimuli. Table XV depicts the animals used, the number of trials necessary to master the problem, and the percentage of right response on the last 100 trials. A comparison of this table with Table XIV and of Graph 13L in Fig. 8 (the curves for the present group) with Graph 13 of the same figure shows no marked difference between the two—so little, in fact, that we are not warranted in making the statement that it is easier to associate a motor response with light than with sound when all other conditions are constant. It is preferable to account for this small difference on the basis of the effect of transfer of learning.

TABLE XV

Rat	Training Trials	Test Trials	% on Last 100
53	120	50	92
54	100	40	90
55	120	50	92
56	120	50	91
Average	115	47.5	91.5

In Group XIV where the sound was presented one second after the pain (in most cases after the motor response to pain) the conditions were in all other respects the same as those for Group XIII. Under these conditions we hoped to secure data showing the relative difficulty in making the association in the backward direction when the two members to be associated are presented continuously and when they are presented with an interval of one second between them. The data for this group are given in Table XVI. The last column of this table is misleading unless it is understood that this last 100 trials include four series (80) of the regular training trials and only two series (20) of the test trials. This is accounted for by the fact that the test trials were interpolated after the first 60 regular trials and after each 20 subsequent trials. This was done because of the apparent slow rate of making the association under these conditions. The rate of increase in the strength of the association can be observed more accurately by reference to Graph 14 in Fig. 8. This curve is constructed on the basis of percentages of correct response on the test trials only. Although all the animals made occasional correct responses to the sound stimulus during the test trials no real learning is observable at the end of 380 training trials. It is to be regretted that the work of this group was not continued, but sickness caused the experiments to close at this point. Yet, several features of the results deserve comment: 1) Measured in terms of the number of trials necessary to make the association function in the backward direction, it is much more difficult to form the association when the terms presented are separated by one second than when they are presented continuously. The animals in the group to which the stimuli were presented continuously learned the association in an average of 130 trials, while those in the former group showed no improvement at the end of 340 trials. With more training the animals of the group might have learned the association, but we have no evidence that they would have done so. 2) Judged upon

TABLE XVI

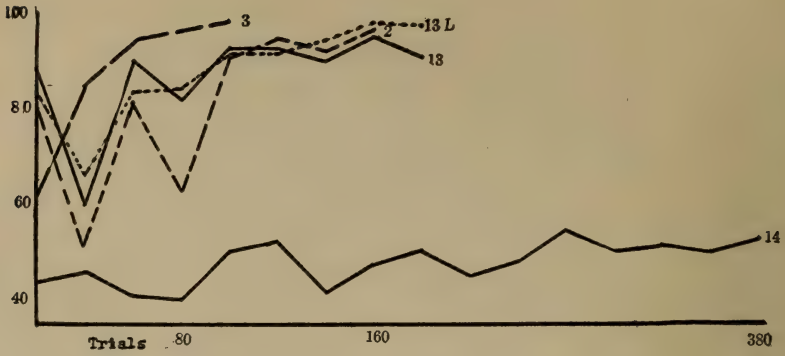
Rat		Training Trials	Test Trials	% on Last 100
57		320	70	73
58		340	80	77
59		380	90	68
60		320	70	76
	Average	340	77.5	73.5

the same basis, it is more difficult to learn to associate a motor response with an auditory stimulus when the latter is presented one second after the former has occurred than when it is presented one second prior to the initiation of the motor response. Under the latter condition Group III learned the association on an average of 128.5 trials, while under the former conditions Group XIV failed to make the association, although they had an average of 340 trials. 3) When the stimuli are presented in immediate succession it is more difficult for the association to function in the backward than in the forward direction. To account for the comparative ease with which the animals made the association in the backward direction under these conditions, one may assume that the new stimulus was not associated with the old stimulus. This response and the new stimulus were experienced simultaneously, and association is due to this simultaneity.

Summary:

1. Association in the backward direction is only slightly more difficult than in the forward direction when the terms to be associated are presented in immediate succession. This small difference is by no means conclusive.
2. It is much more difficult to learn an association in the backward direction when the terms are separated by one second than when they are presented in immediate succession.
3. It is more difficult to associate a motor response with an auditory stimulus when the latter is presented after the former has occurred than when it is presented before the initiation of the motor response.
4. The data found do not warrant the statement that it is easier to associate a motor response with light than with sound when the stimuli are presented in immediate succession.

2. *Simultaneous and Successive Presentation.*—The present investigation was not undertaken primarily for the purpose of gathering experimental data relating to the well known controversy between simultaneous and successive association advocates, but the condition of our problem made it profitable to do so. Experimental data thus far reported are divided on this



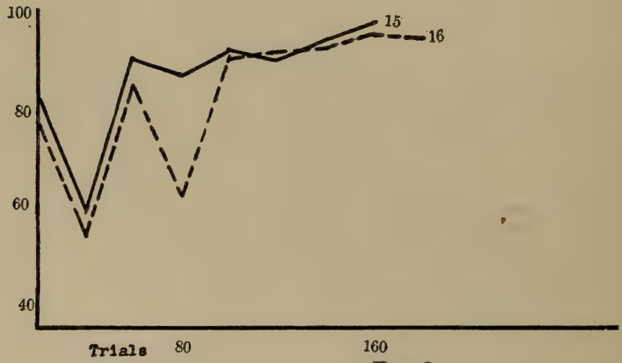


FIG. 8

FIG. 9

In Fig. 8 curves 2 and 3 are reproduced from Fig. 4; curve 13 is the learning curve for Group XIII on sound, and curve 13L is for the same group on light. Curve 14 represents the work of Group XIV. In Fig. 9 curve 15 is the composite curve for simultaneous groups (Groups I and VII); curve 16 is the composite curve for successive groups (Groups II and VIII).

point, but the better controlled experiments report data indicating the superiority of the simultaneous mode. The difference in materials used, experimental conditions, and methods of procedure, no doubt account for the conflicting results. Our data support the superiority of simultaneous presentation. Almost all results thus far reported have come from investigations with human subjects, a fact which gives our data the more significance.

1) Simultaneous Mode of Presentation.—Two groups of animals learned to make the association when the two stimuli were

presented simultaneously. With the one, electric shock and buzzer were used; with the other, electric buzzer and light. The previously discussed test trials were interpolated after each series of 20 training trials in order to check the rate of learning. These tests were not made with Nos. 2 and 9. These continued on the regular learning series until they had had 100 trials before the test series was entered. These animals do not appear to have had any advantage over the other animals of this group where the special tests were entered earlier. These special tests were not expected to assist in learning the association, but they do not appear to have hindered it.

When the pain-buzzer group (Group I) had learned to respond negatively to the first stimulus, pain, buzzer was sounded simultaneously with pain, and the problem was to transfer the negative response from pain over to buzzer. In Table XIV the number of trials necessary to master the problem and the strength of the association are given. The number of test trials given is not shown in this table, but is used in constructing the curve in Fig. 9.

TABLE XIV

Animal	Training Trials	% on Last 100
2	120	91
9	100	96
14	100	91
31	100	91
32	120	90
33	140	92
Average	113.3	91.6

No marked individual differences appear. Although the average number of trials necessary to learn the association is 113.3, in each case where the test trials were given the animal had so completely made the transfer that at the end of 60 trials he made 90 per cent on the test trials. However, because 90 per cent on the last 100 trials had been adopted as a standard, each of the animals was given additional trials on the training series.

The four animals of Group VII had not only learned the negative response to pain, but had transferred this response to the sound stimulus. After the habitual response to the buzzer had been built up an electric light was presented simultaneously with the buzzer. It was hoped by this means to determine the rate and number of trials necessary to transfer this response from sound over to the simultaneously experienced light. During the first series of 20 trials only a slight disturbance was shown, the average percentage of correct response for the group being 86. The animals continued to respond to the sound but in the presence of light, a rather disturbing factor. The special series of 10 test trials broke down the response. Only 24 per cent above the minimum was made by the group, with two animals falling to 10 per cent above. Table XV contains the individual records.

TABLE XV

Animal	Training Trials	% on Last 100
49	100	93
41	100	96
43	100	91
52	100	92
Average	100	93

At the end of 100 trials each animal had made the association. The transfer again was very rapid, and only a comparatively small number of trials were necessary to make the association.

The learning curves for these two groups, given in Fig. 9 depict the rapid growth of the association. The construction is based on the per cent of right responses in both the regular series and the special test trials. The first and each alternate point thereafter is determined by the average per cent of right response for the group in 20 regular training trials. The other points are the average per cent of efficiency for the group in 10 special test trials. From the curve it is seen that Group VII formed the association by the end of 40 trials, for at no time after this did the percentage of the group fall below 90.

When these two groups are compared there are two points to be noted. 1) In both groups the percentage of right response on the first 20 learning curves is practically the same. In these trials the animals were reacting to an old stimulus but in the presence of a new one; namely, sound for Group I and light for Group VII. The two stimuli seemed to offer about equal disturbing effect at this point in the learning. 2) When the first special test series was given a complete breakdown occurred in Group VII while Group I only partially broke down. The drop in percentage of right response was from 85 to 55 in the former, and from 84 to 62 in the latter. This breakdown was only temporary, for in the next special series the percentage rose above that of Group I. Light seems to be more difficult in the beginning, but measured on the basis of the required number of trials in the two groups there is little or no difference.

2) Continuous Mode of Presentation.—The work of these two groups (Groups II and VIII) was reported with the other groups on successive association, but in the table below the results are reproduced in order to get a quick comparison of the two modes of presentation. The curves presented in Fig. 9 show the different rate of learning the association by the two groups.

TABLE XVI

Simultaneous	Trials
Group I	113.3
Group VII	100
Continuous	**Trials**
Group II	120
Group VIII	100

With these results before us we are able to observe the following facts: 1) Associations are possible with either the simultaneous or the successive mode of presentation. 2) Our data indicate the superiority of the simultaneous mode of presentation, in that under these conditions the association is more readily made—*i.e.,* fewer trials are necessary to establish it than when the stimuli are presented in succession. 3) The theory that associations are possible only when the terms to be associated are presented simultaneously is not supported by our results.

3. *Learning the Negative Response to Pain.*[1]—All the animals

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[1] For method of procedure, one may with profit re-examine the last few pages of Section III above.

used in the experiments of this monograph learned the negative response to pain before beginning work on their respective problems. In training the animals to make this response two mazes were used. With one group of 23 animals the maze shown in Fig. 1 was used; and the maze described by Carr and Freeman in the report of their studies[2] was selected for the training of the latter group. The results of the former group are presented first.

The results for the 23 animals trained on the first mentioned box are given in Table XVII. The first column gives the animal; the second, the number of trials necessary to establish the desired response, and the third the actual number of turns made by each animal before he attained the adopted standard. Since 90 per cent of correct responses must be made within the last 100 trials, it is obvious that few turns were made until near the end of the

TABLE XVII

Animals	Trials	No. of Turns to Pain
1	820	112
2	770	98
4	1015	157
9	745	107
10	684	99
11	890	135
12	901	151
13	1024	136
14	1009	113
16	1079	118
19	753	132
21	715	119
22	914	128
23	803	143
24	926	99
25	1045	123
26	1119	102
27	1134	106
28	937	101
29	1159	160
31	1376	124
32	979	109
33	1251	116
Average	960.6	121.2

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[2] *Op. cit.*, p. 466.

training. The number of trials necessary to master this problem varied from 684 for No. 10 to 1376 for No. 31, while the average for the group was 960.6. Since no pain was given in 30 per cent of the trials these animals on the average encountered pain 672 times before learning to make the desired response.

Because of the large number of trials required and the amount of time lost in the long zigzag runways of this box, it was thought expedient to use a simpler box in training the remaining animals. The apparatus used by Carr and Freeman was selected with the hope that time could be saved each day by its use. Future experiments required that the animal be able to hold the standard of correct response in the box presented in this paper and not in the simpler one. It was necessary, therefore, that both apparatus be learned, a necessity which made it seem probable that the group working in the new box would require more trials than the other group. In order to avoid any delay in making the transfer of correct response from one box to the other, the animals were each day given one run in the long maze after having completed the day's work in the short one. In this way the two mazes were learned together: the first being partially learned, then the second partially learned, and finally the first and then the second completely learned. In the light of the findings of Wiltbank[1] this was thought to be the best possible method. Table XVIII gives the number of animals, the number of trials, and the number of turns made by each animal before reaching the required standard of efficiency. The range of trials required is from 394 to 1196; the average for the group of 15 rats is 694.4. Since in 30 per cent of these trials no pain was given, the animals received pain 486 times before learning to respond to it negatively. Not only did this method save time in giving the series from day to day, but on the average it reduced the number of presentations of pain from 672 (the number required for the long-maze groups) to 468—a saving of 204. There are at least three possible explanations of this difference: 1) The increased complexity of the longer box increased the difficulty of the prob-

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[1] Wiltbank, R. T., "Transfer of Training in White Rat Upon Various Series of Mazes," *Beb. Mono.*, Vol. IV, 1919.

TABLE XVIII

Animals	Trials	No. of Turns to Pain
35	772	103
37	1196	102
38	787	115
39	817	108
40	429	98
41	840	94
43	578	91
45	651	104
46	679	93
47	394	88
48	652	94
49	585	96
50	654	91
51	614	98
52	768	107
Average	694.4	98.8

lem. The larger number of compartments greatly increased the number of turns and the distance to be traversed in ecah trial, thereby causing confusion. The records show a small number of instances where an animal, after having run the maze for several hundred times, became lost and ran back and forth through three to five adjacent compartments several times before he proceeded to the food-box. 2) With the short box the trials were more frequent than with the long one. It took less than half the time to run the smaller maze; thus, the trials could be given twice as frequently. 3) The getting of food was delayed by the long runways of the larger box. The influence of delaying food, the apparent motive for the animal's effort, is not known, but we are of the opinion that it was an important factor with our animals.

Although the number of trials was reduced when the shorter box was used there was really no difference in the rate of learning between the two groups after learning once began. A study of the learning curves in Fig. 10 confirms the accuracy of this statement. In constructing these curves only the last 500 trials for each animal were used. This was done for two reasons: 1) All observable learning is included in this period. 2) It per-

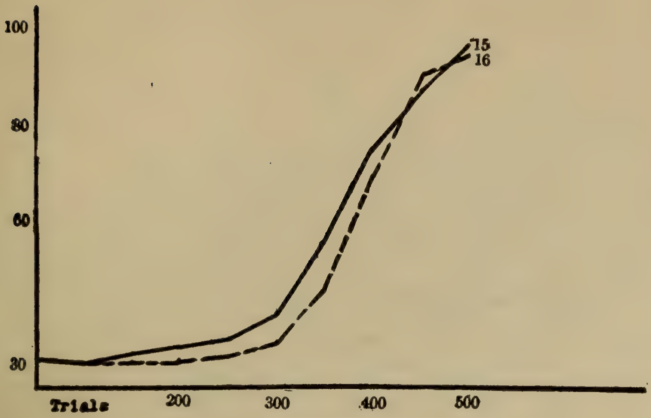

FIG. 10

Curve 15 in Fig. 10 represents the rate of learning in the last 500 trials for groups of animals trained in our maze: Curve 16, the rate for those trained in the Freeman maze.

mits a comparison of the rate of learning at the exact time learning was in progress in the individual cases. This is not possible in either group if the curve is plotted on the basis of trials made from the beginning of the problem, for some completed the training before others showed signs of improvement. In each group there is a period of no apparent learning followed by a short period of rapid learning.

The large number of animals in each of these groups and the almost uniform difference between the number of trials required to master the problem are conclusive evidence that the negative response to pain can be more easily learned in a simple maze than in a more complex one, and that the rate of learning is approximately the same from the time obvious learning first appears until the problem is mastered.

V.

INTERPRETATION OF RESULTS

Now that the experimental results have been presented there remains the important task of ascertaining, as far as we can do so, the relative scope and value of the different factors involved. In making this interpretation and evaluation the different theories that have been advanced by the various investigators to account for the experimental results previously reported will be discussed. The following questions set forth the chief points of discussion: 1) How can association be accounted for when the two terms to be associated are presented with a certain time interval between them? 2) How can association be made when the two terms are presented in the reverse order? 3) Is the simultaneous mode of presentation superior to the successive? These questions are considered below in the order given.

1. The nature of the connection established between the two members of a pair of external stimuli, the first member of which is presented for a definite time and is succeeded by the second after a definite interval, is the problem to the solution of which the numerous experimental investigations, beginning with Ebbinghaus and continuing through the past 25 years, have aimed to contribute. Thus far, three theories have been advanced for the explanation of this phenomenon. 1) One may assume the survival of a memory image of the first member of a pair of stimuli during the time interval which separated it from the second stimuli. The second term of the association, then, coincides in time with the "gradually-dying-away" memory image of the first, and it is due to this simultaneity that the association is formed. 2) The connection between the stimuli may be mediated by some third factor which is not only common to the two stimuli, but is also present during the interval which separates them. For example, a series of syllables may be more successfully memorized by associating each syllable with its position in

a temporal sequence. The continued running activity of the animal and the external environment were possible third factors in our experiments. If the running activity, which was almost always present, did serve such a mediating function no increase in difficulty in forming the association over different time intervals should have been evidenced. Nor can this variation among the different groups be accounted for on the basis of the external environment, for it remained constant. 3) The third theory assumes that the two terms may be associated directly, *i.e.,* when the first member of a pair of stimuli ceases the actual nervous excitation is not finished but continues for a time, gradually diminishing in strength. The second member coincides with the diminishing phase of the preceding one, and the association is due to this simultaneity of the two experiences. Although the external stimuli are presented in succession the internal experiences are in a large measure coexistent.

In the light of our data, this "gradually diminishing nervous excitation" continues for at least six seconds. This after-phase may account for the distinct, though disproportionate, increase in difficulty in making the association over larger and larger intervals. If this difficulty in making the association is a measure of the waning strength of the after-phase of the first term, our data warrant the statement that little or no loss in strength is experienced during the first second, but by the end of two seconds a marked weakening is observed. For longer intervals the diminution is gradual with no marked breaks observable. This is in agreement with Froeberg's finding that association can be formed over an interval of at least five seconds.

Although the hypothesis of direct association seems to be the best explanation of successive association, the following possible objections to its acceptance should be pointed out: a) When human subjects are used it may be assumed that all memory and thought connection are not wholly excluded. These connections are many, and some are very difficult to overcome. b) Where activities are interpolated to destroy the memory image of the preceding term it may be assumed that these activities themselves mediate the association. However, in our experiments with animals these objections are not valid, for few believe that white rats master problems by the use of memory images and concepts. c) A third and perhaps a more vital objection to this theory has been made by Carr; namely, that while one can easily conceive of the persistence of a neural activity for a short interval of time on the principle of inertia, yet the assumption of an indefinite continuance rather taxes one's credulity. For this reason a fourth type of explanation is perhaps the most acceptable. 4) This, the last theory advanced, explains the connection formed between the two stimuli in terms of the decreased resistance of the motor center. The connection is mediated by so decreasing the resistance of the motor center that the one term will become the adequate motor outlet for the nervous impulse aroused by the other. Such a conception is based upon the well known and generally accepted theory of synaptic resistance. The two theories have in common two assumptions: 1) Each sensory impulse tends to follow that motor path which for the time offers the minimum of resistance. 2) The resistance of any center is decreased by an increase in metabolism in that center. If the resistance of one motor center has by continued practice been so reduced that its readiness for response is much greater than that of any other motor outlet, there are no reasons why an effective association cannot be formed over a considerable interval of time.

Since there was no observable third factor mediating the association in our work and since survival of the memory image most likely is not a factor in the behavior of the white rat, there remain but two possible explanations for our results: namely, either the theory of the "akoluthic" phase or the reduced resistance of the motor center.

2. Our discussion has thus far been concerned with the phenomenon of successive association when the two members to be associated were presented in a certain definite temporal relation. We shall now examine successive association when formed under the same conditions except that the order of the presenta-

tion of the terms is reversed. Under these conditions the connection between the terms may be explained upon the same hypothesis as in the experiments in the forward direction. For there is no reason for the assumption that, since the animal has made a certain motor response to the first term, the neural excitation produced by this term suddenly ceases. On the contrary, if the stimulus gets sufficient attention to call out this motor response its neural effect might be expected to diminish more gradually than when no reaction is made to it. The assumption is made here that the "akoluthic" phase diminishes at a rate proportionate to the intensity of the stimulus, which, of course, we have not proved. Although our data are not conclusive on this point they indicate greatly increased difficulty in learning the association when the terms are presented in the backward order. This increase in difficulty may be explained by factors of the situation other than the "akoluthic" phase—factors incident to the reversal of the stimuli. 1) The animal had previously been thoroughly trained to turn when pain was presented. As this response was learned it was easy to observe a change in his behavior from a careless, random run to a slower movement which resembled human behavior when in a state of *expectancy*. This method of approach made him more responsive to any stimulus presented at the time. He, therefore, readily transferred the response from pain to sound when the buzzer was presented before the motor response. If, however, the buzzer was presented after the motor response had occurred this state of "expectancy" was absent, and the transfer of response was more difficult. 2) The previous training had taught the animals that when once turned they must retrace the maze and select the opposite side in order to secure food. Without exception this was true. Hence, after they turned around for pain and started on a *never-failing* road to the food-box, it was scarcely probable that they would proceed in the same state of "expectancy" as before. Daily observations showed that they did not. 3) One may assume that the two terms were associated, but that it was more difficult for them to function in the backward direction. The conditions for learning here are probably more difficult than in learning the negative response to pain.

3. In most of the experiments reported the problem of successive and simultaneous mode of presentation has been important. In these, successive presentation has been thought of as *immediate* succession of the members of the stimuli. The results are divided as to the better mode of presentation, but the majority of the data favor the simultaneous method. The writer is of the opinion that the difference in results is best accounted for by the difference in the material used in the several experiments and difference in the method of procedure.

The most important point of difference in method of procedure is the attempt to secure an exposure time in successive presentation equal in length to that in simultaneous presentation. If each member of the pair in the successive series is exposed for the same length of time as the pair of simultaneous stimuli the learning time is twice as long in the successive as in the simultaneous presentation. Wohlgemuth felt a necessity for making this exposure time equal in length if comparative data were to be secured. To accomplish this he devised two methods: 1) The exposure time for the simultaneous pair was made twice as long as for each member of the successive pair, the number of presentations remaining the same; 2) The exposure time remained the same while the number of presentations were twice as great in the simultaneous as in the successive pairs. Froeberg objects to both of these methods. To the first his objection is that it "implies that the strength of an association depends upon the *exposure time of the stimuli* only, regardless of whether or not the pair is exposed at the same time, and thus contradicts the theory which was to be proved, namely that association takes place only while the two experiences are present in consciousness." Of the second method his statement is that "it disregards the effect of the distribution of presentations."

The criticism of the second method of equalizing the exposure time is pertinent, but so much cannot be said for the first. This first method is good or bad, depending upon which phase of the problem is under investigation. If the problem attempts to determine the effect of the exposure time this is a good method, but if the aim is to determine whether or not two terms when presented simultaneously offer greater interference to each other than when presented successively, thereby hindering the process of learning, the method is inept. The method used in our experiments and also by Froeberg is preferable in such investigations. By means of it each term is exposed for an equal time, regardless of the mode of presentation. In simultaneous presentation the exposure time of each of the two terms is not only equal, but the presentations actually coincide in time. In the successive mode the exposure time of each of the terms is also equal, but the presentations succeed each other in time. It is obvious that such a method reveals the relative value of the two modes of presentation on the basis of term interference.

Our data do not indicate term interference when the two terms are presented simultaneously. On the other hand, they indicate a more rapid learning with the simultaneous than with the successive mode. These findings are in agreement with those of Chamberlain, Bigham, Wohlgemuth, and Froeberg, when the latter used nonsense syllables as material.

As indicated above, the results have varied when different materials were used. Disconnected words, associable words, nonsense syllables, syllables, letters, colors, and diagrams have served as materials for the experiments thus far reported in the field of human psychology. From a study of all the results obtained the following conclusion, reached by Froeberg, appears to be true: If the material is such that the pair of stimuli form an organic whole or can be attended as a unit, simultaneous presentation is preferable; if it is such that the materials stand as separate entities, or must be attended to separately in order to be apprehended, successive presentation is preferable.

In the field of Animal Psychology a certain motor response and a definite external stimulus have served as the two terms to be associated. After a motor response to one term is built up the second term is presented in a certain temporal relation to the first—*i.e.,* either before or during or after the motor response has occurred. In the present experiments light and buzzer were introduced in this way in relation to the motor response, and the results indicate in both instances the superiority of simultaneous presentation. The learning was more rapid when light was used than when sound, but this fact is due rather to transfer of training than to a difference in stimuli.

VI.

SUMMARY AND CONCLUSION

1. The number of trials necessary to learn the association does not increase proportionately with the increase of the time interval between the presentation of sound and pain.

2. Upon the basis of the number of trials necessary to make the association, the difficulty of the problem steadily increases with the increase of the time interval between the presentation of sound and light, but this increase is not proportionate.

3. Our data indicate no marked difference in difficulty for the continuous and one-second interval presentations; likewise, no marked difference is manifest for the intervals above two seconds. The point of disproportionate increase is between one and two seconds.

4. The excess in the number of trials required for the animals to transfer a motor response to sound over the number required to transfer this response to light is perhaps due to the sense material used, yet the transfer of training is an important factor here.

5. Association in the backward direction is very little, if any, more difficult than in the forward direction when the continuous mode of presentation is used. If, however, the two terms to be associated are presented with a time interval of one second between them, the association in the reverse direction is perhaps impossible.

6. Under our experimental conditions and with the sensory material used, our data indicate a slight superiority of the simultaneous mode of presentation. In order to show the relation of our results to those of earlier investigators of simultaneous and successive association, we may classify the findings of the latter upon the basis of exposure time per term. Wohlgemuth (two experiments), Bigham, and Chamberlain used an unequal exposure time per term, the inequality favoring the simultaneous mode, and in every instance they found the simultaneous mode

to be the better. In the experiments of Wohlgemuth (one experiment), Froeberg, and Freeman the exposure time per term was equal, and, except for Froeberg's work with nonsense syllables, all results favor succession as the better mode. Froeberg thinks his exception is not a proof of the superiority of the simultaneous mode, but is rather to be accounted for by the sense material used. Although our results indicate a slight superiority of the simultaneous mode, this is not sufficient to be of great significance. These data seem to warrant the conclusion that when the exposure time per term is unequal the simultaneous mode is the better; when it is equal the better mode of presentation depends upon the materials used.

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DYNAMICAL PRINCIPLES IN RECENT PSYCHOLOGY

By MADISON BENTLEY

and

MEMBERS OF THE PSYCHOLOGICAL SEMINARY

I.

Man's earliest conception of mind appears to have been that of an intangible and inscrutable substance which was at once an active personal agent, a private possession, and a unique source of power and authority. The more detached and less emotional accounts of mind, accounts which have put description before possession and understanding before use, arose, as a natural sequence, very much later. But the two views once established became enduring and persistent rivals. To this day they have contended together.[1] The earlier view has been generally represented in the "doctrine of the soul,"—a doctrine encouraged by philosophy, theology, and the unreflective opinion of common sense and uncritical knowledge. The strongest support of the later view has come from the natural sciences, which have lent it both a pattern and a methodological background. The development of the physical sciences has, it is true, laid stress upon a description of the world in terms of the transfer of energy within and between systems,—a description which has seemed to leave mind out of account. At the same time, the insistence of these sciences upon controlled and verifiable observation of events has been carried over to the mental facts and thus has indirectly promoted a descriptive psychology of process.

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[1] Writers who look upon the dynamical conceptions as new and modern display a distorted perspective. H. W. Carr, *e.g.,* declares in the Preface to his English translation of Bergson's *L'energie spirituelle;* "In recent years we have witnessed the opening up of a new and long-unsuspected realm of fact to scientific investigation, the unconscious mind. The very term seemed to the older philosophy to imply a latent contradiction, today it is a simple general description of recognized phenomena."

The older, active or dynamic view of the "soul" has not, in spite of the scientific trend of our own generation, been given up. All sorts of extra-psychological sanctions—philosophical, biological, medical, etc.,—have sustained it. With these latter sanctions we are not here concerned. But psychology itself has found, and it continues to find, reasons for conceiving mind as a power or force, as an agent which originates, directs and controls. These reasons are many and varied; nothing less than a history of modern psychology could expound and interpret them. Our own study is much less ambitious. It proposes to examine a few outstanding accounts of mind which have been substantially based upon dynamical principles. These accounts represent many schools and various traditions, and they sustain unlike interests in the facts and laws of mind. By "dynamical" we mean that they consider mind under the category of *activity:* that they represent mind as being or possessing a central force or power which is causally related to other forms of existence and to physical events. Our examination of these chosen systems has made it appear that the dynamical elements in recent psychology are of at least four kinds; *i.e.,* mind is regarded as a creator, an initiator, a selector and repressor, and an organizer. Possibly these forms of activity differ only in degree and in shading, and some writers pass easily in their expositions from one of them to another; but they seem to represent logical differences as well as differences in point of view and perspective which have not been carefully defined.

We have chosen men who have either exemplified important historical doctrines or who have represented an aspect or phase of psychology of serious import to the developing and expanding science. Their own distinct contributions to psychology have been by no means equivalent. The writers chosen for critical study in the seminary are James, Woodworth, Janet, Bergson, Freud and McDougall.

II.

William James

(C. A. Ruckmick)

There seems to be no ambiguity concerning the general type of mind that James describes in his *Principles of Psychology*. It is always an active, energetic, dynamic agent of the psychophysical organism. Statements illustrative of his point of view, taken from various contexts, are:

"Consciousness is *in its very nature impulsive*" (II, 526). "The *impulsive quality* of mental states is an attribute behind which we cannot go" (II, 551). "This dynamic (I had almost written dynamitic) way of representing knowledge has the merit of not being tame" (I, 369). "To my brain, however, I am dynamically present, inasmuch as my thoughts and feelings seem to react upon the processes thereof" (I, 214).

When we proceed, however, we find here and there points that are not so clearly made and distinctions that are not so sharply drawn. But the primary descriptions, even in detail, are emphatic.

First of all consciousness in its several phases is a *selecting* agent.

"Consciousness is at all times primarily *a selecting agency*. Whether we take it in the lowest sphere of sense, or in the highest of intellection, we find it always doing one thing, choosing one out of several of the materials so presented to its notice, emphasizing and accentuating that and suppressing as far as possible all the rest" (I, 139).

Selection goes on specifically on all planes of mental activity.

"To begin at the bottom, what are our very senses themselves but organs of selection" (I, 284). "The mind selects again. It chooses certain of the sensations to represent the thing most *truly*, and considers the rest as its appearances, modified by the conditions of the moment" (I, 285; cf. I, 78). "Out of all present sensations we notice mainly such as are significant of absent ones; and out of the absent associates which these suggest, we again pick out a few to stand for the objective reality *par excellence*" (I, 286). "It [thought] is interested in some parts of these objects to the exclusion of others, and welcomes or rejects—*chooses* from among them, in a word—all the while" (I, 225; cf. I, 284).

Again aesthetic unity is said to be due to the mental elimination of discordant effects and "ascending still higher, we reach the plane of Ethics where choice reigns notoriously supreme. An act has no ethical quality whatever unless it be chosen out of several all equally possible" (I, 287).

All of this is nothing more than an elaboration of James's original thesis, that mind can be detected by two tendencies, (1) the pursuance of future ends, and (2) the choice of means for their attainment (I, 8, 11). Consciousness is efficient in these offices throughout: it is a fighter for ends and is endowed with causal efficacy in the fight (I, 141-143). There seems to be no doubt in James's opinion of the mind's purposive character as a background for the operations of choosing just described or of the mind's power to enact what it chooses to select. The point at which consciousness makes itself directly felt as a power is in volition and attention. Here there seems to be some systematic ambiguity, however, for we learn at one place that attention is not a new or mechanical force, but an effect produced by the environment (I, 450-454), and at another that it is in part a force, spiritual in its essence (I, 454, 468). And so with volition; for we read that "will is nothing but attention" (I, 447), and that volition involves an effort to attend and a consent (II, 568).

As a matter of stern fact James admits that psychology, the empirical science, must yield the question of conscious initiation of process through the will to the realm of speculation. It is more satisfactory to hypothecate, says James, a consciousness that can step in, through the will to attend, and regulate the flow of the mental life, even if it "could only be to hold some one ideal object, or part of an object, a little longer or a little more intensely before the mind" (II, 576). By a faith grounded in other than empirical or even logical considerations, then, consciousness is also an initiative agent. It is capable of adding impetus out of its storehouse of reserve energy whenever the odds are against it. In detail, "nerve-currents . . . . must in this case be supposed strengthened by the fact of their awaking one consciousness and dampened by awaking another. *How* such reaction of the consciousness upon the currents may occur must remain at present unsolved" (I, 142).

Consciousness is, then, primarily an actively directing agent. It continually selects both among its own processes and indirectly, through its supposed influence on the nervous system, among physiological processes. This form of initiation, however, is more regulative in action than it is wholly creative.

R. S. Woodworth

(Mary A. Henry)

Professor Woodworth has recently written an outline of "Dynamic Psychology"[2] The book is, as the author says, a study in the "workings of the mind" (43). It regards in an active and energetic way the causal relations of mind and behavior. Those bodily instruments and organs which are involved in the neural and motor functions it conceives as "mechanisms" while the *causes* of neural discharge and the motives and springs of action, on the other hand, it calls "drives." The drive in a machine, the author describes as "the power applied to make the mechanism go" (37). Stimulus is drive; one part of the nervous system may drive another; the "inner tendency" toward reaching a goal is a drive; mental processes possess an "inner dynamics" (38-43); willing is the development of fresh motive power (149); reasoning implies an "access of energy" in an "obstructed tendency" (147), and the "higher and more inclusive self" is capable of resolving inner conflict and so of making the individual free (152). So many forms has the "drive." At times it is obviously physiological, representing the release or the initiation of energy in some part of the nervous system; but in other contexts it appears to bear a direct reference to mind,—as in the motive to selective action, curiosity in learning, interest sustained in objects and pursuits, and impulses directed toward the conquest of obstacles.

This dynamical factor, represented in Woodworth's "drives," is not easy to define. Often it appears to be little more than a faculty to which, as a cause, observed facts are referred;—so the "motive forces" of the native equipment of men and animals, the "innate tendencies," "instincts," and "special capacities." Observed facts are referred to unknown forces, tendencies and potentialities, which then become hypostatised as drives, not unlike the traditional faculties and the mental powers and capacities of Gall and Spurzheim. Because of their conceptual and hypothetical origin, it is difficult to say whether, or just when, they belong to "consciousness" and when to bodily function. So far as mind is implied, Woodworth's use of dynamic principles appears to suggest *initiation* and *selection,* very much as we have found these things in the writings of William James.[3]

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[2] Woodworth, R. S., *Dynamic Psychology*, New York, 1918.

Pierre Janet

(Elizabeth Rutherford)

A characteristic type of mental activity, a type which has appeared in various psychological—and especially psychopathological—contexts in the last generation, is represented in the writings of Dr. Pierre Janet, a pupil of Charcot's. It appears in Janet's works as early as the 80's, where the French physician seeks a psychological basis for the symptoms of hysteria and allied disorders; *i.e.,* for the "automatic" phenomena of catalepsy, somnambulism, anaesthesia, and the like.[4] Janet's temper, as well as his training and traditions, has disposed him to reject the physiological or "reflex" explanation of these disorders, as proposed by Haidenhain, Maudsley, and Despine (*L'autom.,* p. 21). He prefers a "psychological" explanation. It is, as he thinks, just in these abnormal states that the simplest and most rudimentary facts of mind come to light; and for the understanding of them, he appeals to a distinction many times recognized in the history of philosophy, and specifically formulated by Maine de Miran;[5] the distinction, namely, between bare sensation ("la sensation sans conscience, san moi capable de l'apercevoir") and the self or person ("une personne, un moi constitué un, simple, identique . . . . la conscience complète").

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[3] The influence of James is everywhere apparent in Woodworth's little book. It may also be that the author's association with Ladd in the "Elements of Physiological Psychology,"—where the causal efficacy of mind had received a liberal interpretation,—inclined Woodworth toward this form of dynamic doctrine. Again, it appears that this and many other "genetic" accounts of mind, especially those prepared for educational purposes, easily turn to account the biologist's dynamic faculties of innate and inherited capacities, instincts, and powers.

[4] *L'automatisme psychologique; essai de psychologie expérimentale sur les formes inférieures de l'activité humaine,* Paris, 1889.

Now it is this "conscience complète," the "personal consciousness," and its defects in disease and disorder which form the basis of Janet's psychology of the abnormal.[6] That is the active thing which unifies and organizes experience. When the organizer is absent or disturbed, the morbid features of hysteria, hypnosis, catalepsy, and the like, appear. In such grave states as catalepsy, the personality is wholly wanting; mind is reduced to a state "purement affective, aux sensations et aux images." From this total "automatism" of catalepsy, Janet proceeds to build up the organized mind through the incomplete syntheses displayed in somnambulistic and suggestible states, and in the partial automatism of subconscious acts and local anaesthesias. As the exposition proceeds, the antithesis grows between automatism, the sheer existence of sensations and images, and the synthetizing operation of personality. The latter is not a mere principle of association; it is "an activity which synthetizes at each instant of life the various psychological phenomena and which forms our personalized apprehension (perception personnelle) of things" (*L'autom.*, 307). More and more the notion of a power or faculty, as opposed to the passivity of "mere sensation," developes in the exposition, and more and more it appears that the mental disorders are not primarily disorders of process or of the automatic ligation or "association" of processes, but rather defects or "lesions" of a power (puissance), "la faculté de synthétiser les sensations en perception personnelle (*ibid.,* 314), which lead to a real disorganization or "dis-assembling" (désagrégation) of mind.

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[5] In *Anthropologie* (*Œuvres inédites,* 1859, iii), 362, 405.

[6] Janet acknowledges (*L'autom.,* 399) an anticipation of his general doctrine of ruptured personality in an anonymous brochure of 1855: *Seconde lettre de gros Jean à son évêque au sujet des tables parlantes, des possessions et autres diableries.* Spiritistic exhibitions are here explained by the assumption that the organism is directed "par l'intelligence sans l'intervention de la volonté. In his acknowledgment Janet suggests,—perhaps more pointedly than he realizes,—the derivation of his dynamic principle from the Wolffian faculties.

In his later works[7] Janet applies in various directions this central notion of a synthetizing activity which is weakened, disturbed, divided or broken down in hysteria, "double personality," psychaesthenic states, neurotic conditions, and so on. There is apparent a tendency, as time goes on, to increase the emphasis upon neurological descriptions,—as in the inception of hysteria, which is defined as a "depression, an exhaustion of the higher functions of the encephalon" (*Major S.,* 333) and in the use of such vitalistic terms as "nervous strength," "nervous tension," anatomical "system" and "associations' (*ibid.* 180). Moreover, the frequent use of "dissociation," "mental depression," "tension" and changing "mental levels" has a less dynamic sound than the older expositions. Nevertheless, the main conception of "personal synthesis' remains. It is a dynamic concept which is now very widely used in the pathological literature, where it stands closely related to the notions of "dissociation" and of the "subconscious." It is in its essence a faculty of organization; though it inclines here and there (as when related to the will) to assume the rôle of a creator.

HENRY BERGSON

(COLEMAN R. GRIFFITH)

When we turn to Bergson we pass, of course, beyond empirical psychology to a general, voluntaristic account of the universe; but Bergson's philosophy is so intimately bound up with historical trends in psychology and in the science of life that his exposition of "creative evolution" falls naturally under our present process of sampling. We may leave aside the philosophical antecedents and implications of Bergson's theories; but we shall have to consider the relations of his system, first, to that psychology of the abnormal which has for many years in France capitalized the unconscious and the automatic and, secondly, to the current vitalistic doctrines of the biologists.

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[7] *The mental state of hystericals, etc.,* (Corson, C. R., trans.), New York, 1901, pp. 492, 502, 527; *Névroses et idées fixes* (2 vols.), Paris, 1904, 1908; *Les obsessions et la psychasthénie* (2 vols.), Paris, 1903; *The major symptoms of hysteria,* New York, 1907, 311, 332; *Subconscious phenomena,* Boston, 1910, 53-70.

In Bergson's conception of mind we seem to see Janet's fundamental antithesis of "personal consciousness" and "automatism" spread out upon the whole wide canvas of the universe. At the centre of things is life, the creative impulse, which integrates, organizes, constructs, constantly creates. Life is also mind: it is will: it is struggle: it is opposed to matter. "Consciousness has had a narrow escape from being itself ensnared. Matter, enfolding it, bends it to its own automatism, lulls it to sleep in its own unconsciousness." The history of life is the history of the struggle of consciousness to free itself from "automatism and unconsciousness." "Freedom is riveted in a chain. . . . With man alone a sudden bound is made; the chain is broken."[8] But mind does more than struggle: it produces the novel. "How can we distinguish the force of mind, if it exists, from other forces save in this, that it has the faculty of drawing from itself more than it contains."[9] "Notre volonté fait déjà ce miracle. Toute œuvre humaine qui renferme une part d'invention, tout acte volontaire qui renferme une part de liberté, tout mouvement d'un organisme qui manifeste de la spontanéité, apporte quelque chose nouveau dans le monde."[10]

There is no doubt that, for Bergson, *creation* is the primary and the chief function of mind. The dynamical principle in consciousness, however, also *selects* and *organizes*. In both forms of expression of the *élan vital,* instinct and intelligence, materials used by the creative energy are selected to a given end and also organized. "L'instinct achevé est une faculté d'utiliser et même de construire des instruments organisés; l'intelligence achevée est la faculté de fabriquer et d'employer des instruments inorganisés."[11] Especially as regards intelligence, Bergson explains that "la fonction essentielle . . . sera donc de demêler, dans des circonstances quelconques, le moyen de se tirer d'affaire. Elle cherchera ce qui peut le mieux servir, c'est-à-dire s'insérer dans le cadre proposé."[12]

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[8] Bergson, H., *Mind-energy; lectures and essays,* N. Y., 1920, pp. 25, 26.

[9] *Ibid.,* 27; cf. *L'évolution créatrice,* 4th ed., Paris, 1908, p. 273; *Time and free will: an essay on the immediate data of consciousness,* London, 1910, 140-143.

[10] *L'évolution créatrice,* 260.

Bergson's relation to vitalism has been much discussed. Here it calls for only a comment. To "mechanism" the philosopher of creative evolution opposes "dynamism," a principle which is allied to vitalism so soon as it suggests a creative force in life. Dynamism is, however, more ambitious than most forms of vitalistic doctrine because it is based upon a dialectic of mind and matter. This dialectic leads it straight toward the problems of knowledge and reality. It seeks, that is to say, to interpret the whole universe in terms of vital,—*i.e.,* conscious,—creation.[13]

SIGMUND FREUD

(ANNETTE BARON)

The dynamical principles of Freud are of the same general character as those which we have found in Janet and Bergson. The main emphasis, to be sure, is differently placed. Bergson's chief force is the vital principle, Janet's the personal consciousness, while Freud's may be said to be the "vital, personal unconscious." The main spring of Freud's unconscious is the vital impulse, the *libido,* a force which virtually becomes personalized, even personified, under repression. So are performed the tasks of selecting, condensing, translating, symbolizing and censoring. "The unconscious is the real psychic. . . . It must be accepted as the general basis of the psychic life. . . . Everything psychic exists as unconscious."[14] This "real psychic" Freud constantly describes in terms of "psychic force," "psychic energy," and

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[11] *Ibid,* 152.

[12] *Ibid.,* 163.

[13] A competent and informing review and critcism of the psychological implications of vitalism, in its various classical forms, may be found in H. C. Warren's article "Mechanism versus vitalism, in the domain of psychology," *Philos. Rev.,* 1918, xxvii, 597-615.

[14] Freud, S., *The interpretation of dreams,* N. Y., 1913, 486, 487.

"psychic effort." The dynamic characteristics are applied to two "kinds" or "systems" of the unconscious; (1) to the "Unc. system" where wishes press for fulfillment, and (2) to the "Forec. system," which stands like a "screen" or censor between the exigent wish and its conscious discharge. The second system not only "bars access to consciousness" but also controls bodily movement and emits "mobile energy," a part of which is attention.[15]

Thus we find in Freud an exceedingly elaborate and exceedingly hypothetical account of mind written in terms of force. The account was first designed for the understanding and the relief of certain mental disorders; but later it was variously applied to dreams, humor, myth, lapses of speech and thought, the origin and development of society, and the springs of human action. As regards the use of dynamic agencies, Freud's system lays more stress upon the conflict of forces[16] than we find in the expositions of the French philosophers and physicians. The minds of Janet and Bergson, *e.g.*, are, as we have seen, essentially constructive; while Freud's mind is set against itself. It is torn by strife between the individual and society. In the great works of genius, to be sure, mind is creative; but even here creation appears as a release, almost a by-product, of conflict.

William McDougall

(Carl Rahn)

When we turn from Janet and Bergson to McDougall[17] to discover in what respects his conception of "soul" partakes of a "dynamic" character, we note that his notion of mental activity developes in a fairly definite way toward "creation" and toward "organization." By applying the method of immanent criticism to his presentation, we find that there runs throughout an implicit distinction between the physical conditions for the occurrence, rise and subsidence of mental processes and the *physical correlates* of the same processes. As to the physical *conditions,* McDougall implies that it is when bodily processes come to a "stasis" that the "corresponding" meanings, belonging to the psychical order, arise as conscious perception, thought, and striving. As to the physical *correlates,* we learn that "meaning has no immediate physical correlate in the brain that could serve as its substitute and discharge its functions." Meanings are "products in consciousness of a purely psychical activity" (311), and they are the factors which awaken within us the appropriate emotions and psychical impulses or conations.

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[15] *Ibid.*, 488.

[16] "We explain it [the psychic fission] dynamically by the conflict of opposing mental forces, we recognize in it the result of an active striving of each mental complex against the other." *Amer. J. of Psychol.*, 1910, xxi, 194. Cf. *Vorlesungen zur Einführung in die Psychoanalyse*, Leipzig und Wien, 1918, 64.

[17] McDougall, W., *Body and mind; a history and a defense of animism*, New York, 1911.

Under the *condition,* then, of stasis there becomes operative a "psychical activity" that has no immediate physical *correlates;* and the "products" of this psychical activity are meanings, values and conations. It is in this sense that mind is "creative" for McDougall. This creative activity is conceived to operate in accordance with "psychical dispositions that have been built up in the course of the experience of the race." Being built up, they determine further development and—may we infer?—would thus constitute, collectively, a psychical entelechy with an historical development.

With respect to McDougall's conception of mind as organizer, we find first, that the soul is invoked, after the manner of Lotze, because "the fact of the unity of consciousness correlated with the physical manifold of brain-processes cannot be rendered intelligible without the postulation of some ground of unity other than the brain or material organism" (356). As organizer, the function of the soul is two-fold: (1) it gives unity to the manifold of sensation-processes and (2) it "plays an essential rôle in the building up of the organization of the brain" (279). Concerning (1), the organization of sensations, it is simply to be noted that the independent sensory processes are unified by their integration into "meaning," which is the product of "psychical activity." Concerning the manner in which (2), the "organization of the brain," is affected by psychical activity, we are told that "the product of this psychical activity" (the meanings) "stirs up" the psychic impulses or conation "without which no action is initiated or sustained" (311). The facts, then, are said to point directly toward the view that conation or psychical effort really intervenes in the course of the psychical processes of the brain. And it may be plausibly maintained that all other modes of consciousness serve but to guide or to determine the incidence of conation, the primary and most fundamental form of psychical activity. This organizing of physical processes in the brain by psychical conations is conceived to be a process of "guidance without work," consisting essentially in a "concentration of nervous energy from places of low potential into one system of neurons where the potential is raised to a high level (278),—though McDougall admits that the concentration occurs "in a way which we cannot clearly define."

III.

We find, then, dynamical principles conceived and applied in a variety of ways in current psychologies. For Bergson and for McDougall mind is a creator; for James and for Woodworth it initiates and it drives toward a conclusion. The conception of mental powers held by James and by Bergson also includes choice and selection in a prominent way; while McDougall joins Janet in regarding organization and unification as essential functions of â dynamical mind. Freud's *libido* is also a driving, initiating force, to which is added the active government of thought and behavior by the repressing and selecting power of the censor. Mind, therefore, in our writers is active and dynamic in so far as it creates, initiates, organizes, selects and governs.[18]

When we consider the wide adoption throughout psychology of one or another of the forms and direction of force, as portrayed in these writings, we are led to acknowledge that dynamism has in our own generation exerted a profound influence upon the science. There seem to be two or three special reasons for the psychologist's recent appeal to force. The first lies in mental

[18] These same dynamical principles have also been used in systematic settings by Lotze, Brentano, Lipps, Stumpf, Fouillée and Wundt, and more casually by G. S. Hall, J. R. Angell, E. L. Thorndike, and many others.

pathology, which stood for a long time in a stagnating condition. Its neurological basis was well nigh sterile, and its psychology was jejune and unproductive. There is no doubt that its speculative use of mind as a theatre of forces, producing, organizing, and repressing, has injected into it new life. Its present state suggests the quickening in the sciences of life induced by the principle of natural selection. It may be that now, as then, a long period of speculative fervor will be followed by serious empirical studies. The next subject after medicine to profit from dynamism is the humanistic interpretation of the facts of mind. A unitary, enduring and creative mind has always—since its "discovery"—been a solace to mankind. McDougall's eager support of the psychical researchers and Bergson's sanction of moral "freedom" are significant indications. Neither can we pass over the interest of the student of behavior in the fruits of dynamism. There is no doubt that an account of bodily performance, whether of the animal or of man, of the child or of the adult, of the normal or of the deranged, is rendered vastly more simple and convincing by the admission of a principle of creation, organization and direction. Much that would otherwise fall to observation and to logic is more elegantly done by a force or power. "Instincts," "capacities," and "intelligences" can thus be hypostatized and made to serve as surrogates for facts. The temptation toward dynamism in psychology bears more than a superficial resemblance to the lure of vitalistic "causes" in biology. It is the same temptation under slightly different guises. It is, however, curious to observe that it has become especially attractive in both forms just at the moment when physics is inclined to reject dynamical concepts.

To separate fact and hypothesis is not always easy. I believe, however, that it is possible to distinguish, in a general way, those properties and offices of mind which are subject to observation from our explanatory principles which involve force and which are causally used to account for the facts.

Let us start with the psychology of process,—a persistent attempt to discover by direct inspection mental factors in the flux of experience. This kind of inspection has, as it appears to me, brought to light four significant facts regarding the constitution and the offices of mind. (1) There are *mental processes* which are amenable to description, to arrangement in systems, and to classification. They belong to a unique order, not reducible to the objects and processes of physics and physiology. Again (2) these processes *stand organized* in unique constellations, and they follow each other in sequences which are not duplicated in the physical orders. (3) The organized processes *carry a meaning, i.e.,* they make reference to existence of other orders. As McDougall says, they are in this aspect unique. (4) These organized processes which bear meanings do, when conjoined with bodily processes, *accomplish various ends,* they *operate* in various directions, they *fulfil functions.*

So far, as I think, we are on the level of empirical observation; and so far we seem to stand in no need of any dynamic principle to be imported into mind. For the accomplishment, the operation, the function, whether it be the production of knowledge, the preservation of life, internal or environmental adjustment, or the valuation of objects and of conduct, the only contribution which mind is observed to make is meaning,—memorial meaning or perceptual meaning, existence meaning, or value meaning, anticipation or reflection. If the accomplishment is to be regarded as a function or a performance, then it is always, as it appears, a *psychosomatic function,* a performance which involves bodily terms and mental terms. The term "mental" function (unless it refers to the fact of meaning) seems to me to be without significance. Nothing like energy is observed in mental processes or in their organization; and meaning belongs to a wholly different category from force. On the other hand, the nervous system and the muscles are obviously designed for the reception, concentration, storage, and discharge of energy. If dynamical factors are required for the explanation of the facts of growth, derangement and behavior, the bodily parts and processes involved in the psychosomatic functions would seem to offer the appropriate vehicle for an active or dynamical cause.

The dynamists are obviously right in their contention that mind is centrally and essentially concerned in disease, in organic performance and adjustment, and in the development of the individual and of the race. But to say that it is *dynamically* involved, is to go beyond the facts. The contribution of meaning or of reference appears to me to be the great and unique contribution of mind, the contribution which makes the psychosomatic functions different both in kind and in range from the physiological performances of the body.

At any rate, if a mental force is to be postulated and is to be used to explain the observations of the pathologist and of the student of behavior, it should be recognized that such a postulate is a sheer hypothesis, proposed only for the temporary purposes of explanation. So Freud seems to regard his elaborate "unconscious." To look upon such a principle phenomenologically would be like looking into the ether for the lines of force of a magnetic field or for elastic fingers reaching out from the sun to hold the earth in the clutches of gravity. This confusion of hypothesis with observed and verifiable fact is extremely common within psychology today. It has led to an illegitimate substitution of forces and faculties for the empirical existences of mind and in so doing it has impaired the methodology of the science.

SOME NEGLECTED ASPECTS OF A HISTORY OF PSYCHOLOGY

By Coleman R. Griffith

Psychology stands in a peculiar relation to the sciences of life and to the physical sciences, for it is one of the youngest of Philosophy's children and, on that account, has fallen heir, as do the successive members of any growing family, to a number of family treasures, some good, some bad, and some indifferent. Among other things, it has inherited from the physical sciences a well-rounded methodology and a refined laboratory technique; and from the sciences of life, a "genetic" way of regarding mind in its relation to life. Moreover, in the near future, some one will write a history of the development of scientific concepts and it will then be discovered that psychology has fallen heir, also, to scientific ways of regarding the world at large, ways that became established a hundred years or so before mind was brought into the laboratory.

Now when psychology began to use these methodological and other heritages from the physical and the biological sciences in an attempt to understand mind, the opportunities for research became so great and the problems so insistent that the investigators of mind have been urged on to the present movement by nothing save the enchantment of their own productivity. Psychology became, over night, a realm of laboratory adventure. And within forty years of the founding of the first laboratory, general science is presented with the spectacle of a discipline whose facts already extend beyond the compass of encyclopedic volumes.

So rapid, in fact, has been the growth of the science, and so absorbing are its demands for the immediate future, that an adequate account of its genesis, a serious historical survey of the path by which it has come, is not a part of its immediate program. The psychologist who is at all historically-minded, when trying to gain a perspective in his science, finds himself in the peculiar position of the man who wakes in a strange place and endeavors to comprehend his situation by taking a careful inventory of the furnishings of his room. If the science has come, by virtue of its achievements, to maturity, it must begin to realize that even scientific adventure is hedged about with historical restrictions to be understood and accepted before the adventure itself becomes of real significance.[1] Psychology is not merely the accumulation of fact in monthly journals; it is rather a product of the liberal past and a starting point for a productive future. The historian of psychology must tell us what psychology is, in its largest aspects, by telling us whence its methods and concepts have come and what these mean for its further development.

We have, at the present time, no history of psychology. That is to say, there is no written record of the genesis and development of the discipline as it stands.[2] Our historical researches are limited to the introductory pages of doctoral theses and other major pieces of research.[3] There are, of course, histories of philosophy in which the central theme is mind or sense-perception or mental activity. One cannot neglect such accounts and neither can one forget altogether certain other historical surveys of the life and work of men who may, under protest, be designated psychologists; but the discipline has at present no searching and sympathetic survey of the events and ways of thinking that have led up to and that have grown into our present conception of psychology, its problems, and its methods.

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[1] An expanding interest in the history of science, in this country as well as in Europe, is a token of growth and maturity. It may be traced in the following papers: *Science,* 1915, *41,* 358-360; 1915, *42,* 746-760; 1919, *49,* 330-331; 1919, *49,* 447-448; 1919, *49,* 497; 1919, *49,* 66-68; 1920, *52,* 496; 1920, *52,* 559,562; 1921, *53,* 122; 1921, *53,* 163-164; 1921, *53,* 257-258. That the movement is being taken seriously is further shown by several papers appearing in *The Scientific Monthly.* See, *e.g.,* Gregory, H. E., History of geology, *The Sci. Mo.,* 1921, *12,* 97-126; Woodruff, L. L., History of biology, *ibid.,* 289-309; Bumstead, H. R., The history of physics, *ibid.,* 289-309; Brown, E. W., The history of mathematics, *ibid.,* 385-413.

[2] We are, of course, using the term "history" in the sense of a written account and not by way of reference to the *events* of which an account can be written.

[3] A very few illustrations from a single source will show the temper of such historical surveys; Sharp, S. E., Individual psychology: a study in psychological method, *Amer. J. of Psychol.,* 1899, *10,* 1-20; Whipple, G. M., An analytic study of the memory image, etc., *ibid.,* 1901, *12,* 409ff; Murray, E., A qualitative analysis of tickling, *ibid.,* 1908, *19,* 320ff; Geissler, L. R., The measurement of attention, *ibid.,* 1909, *20,* 473-502; Ruckmick, C. A., The rôle of kinaesthesis in the perception of rhythm, *ibid.,* 1913, *24,* 305-314; Boring, E. G., The sensations of the alimentary canal, *ibid.,* 1915, *26,* 2-5; Dallenbach, K. M., The history and derivation of the word "Function" as a

Of 254 pages which Dessoir[4] devotes to an outline of the history of psychology, 148 describe events prior to 1800, and the remainder of the book barely takes us beyond Herbart. Brett[5] gets as far as Fechner at the end of 900 pages. Villa[6] devotes some 50 pages to a diary of the 17th, 18th and 19th centuries, while the rest of the book,—nearly 350 pages,—draws upon the history of philosophy for a large part of its discussion. The first volume of Baldwin's[7] history goes as far as Hobbes, while the second volume barely enters into the days of "mental chronometry" and the "James-Lange theory." Klemm[8] has done better than some of the others; but even so close a follower of Wundt as he has hardly entered into modern psychology and then has looked back by way of retrospection. Aside from the Wundtian bias, Klemm has written useful prolegomena to a history of psychology.

Histories grow and the past changes as it is seen in the light of new achievements. The cosmopolitan interest of the present-day psychologist is evidence enough that the science is broader than any existing account of its origin and of its growth. Who, for example, would attempt to describe, in advance of serious his-

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systematic term in psychology, *ibid.,* 1915, 26, 473-484; Woods, E. L., An experimental analysis of the process of recognizing, *ibid.,* 1915, *26,* 314-317; Rogers, A. S., An analytic study of visual perception, *ibid.,* 1917, 28, 519-538.

[4] Dessoir, M., *Outlines of the history of psychology,* (tr., D. Fisher), 1912.

[5] Brett, G. S., *A history of psychology, ancient and patristic,* 3 vols., London, 1912-1921.

[6] Villa, G., *Contemporary psychology,* (tr., H. Manacorda), London, 1903.

[7] Baldwin, J. M., *History of psychology,* 2 vols., London, 1913.

[8] Klemm, O., *A history of psychology,* (tr., C. Wilm and R. Pintner), New York, 1914.

torical research, the mental and physical matrix which has stamped in so curious a fashion that current explanatory psychology known as Freudianism? Of the ways of regarding the social mind, of behaviorism and functionalism, of the renewed interest in a "psychology of the soul," and of scores of small problems, we are inclined to speak retrospectively with a superficial knowledge only of the historical facts. In all of these matters, we frequently refer, of course, by way of historical perspective to men and to events; but we have, as yet, no historical research in the field at large comparable in spirit to a recent small but choice example from Titchener.[9]

If, as we have already said, the science is to assume the responsibilities of maturity, it must turn seriously to its history, for such a quest usually tempers the ardor of youth but at the same time saves from stolidity. Now, if there is to be a history of psychology and if we are to speak intelligently of it, we must know upon what principles it is to be established. What significance, for example, will a different interpretation of the two terms "psychology" and "history" have for any statement of the problem and course of historical research in the mental sciences? Obviously, a history adequate to the science need not be three-fourths philosophy and neither must it be a history for purposes of propaganda in favor of any particular school of psychologists.

What, then, do we mean by "history" and by "psychology"? Let us first come to terms with "history." We are not here proposing a philosophy of history and we shall, therefore, be brief and somewhat schematic in describing at least two possible conceptions of the nature of history.[10] The first, which is the more venerable of the two, maintains that history is a chronological account of all that has occurred. That is to say, men sit down and, assuming a temporal sequence, proceed to write a diary of the affairs of the world. Such an account proceeds as if one stood at the end of a street and described the succession of houses in adjoining blocks. An example of this static sort of description is taken from a current history of Italy:[11] "Robert the Wise (of Anjou) (1309-1343), the successor of Charles II of Naples, and the champion of the Guelphs, could not extend his power over Sicily where Frederick II (1296-1337) the son of Peter of Aragon, reigned. Robert's grand-daughter, Joan I, after a career of crime and misfortune, was strangled in prison by Charles Durazzo, the last male descendant of the house of Anjou in lower Italy (1382) who seized the government. Joan II, the last heir of Durazzo (1414-1435), first adopted Alfonso V, of Aragon, and then Louis III, of Anjou, and his brother René. Alfonso, who inherited the crown of Sicily, united both kingdoms (1435), after a war with René and the Visconti of Milan."

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[9] Titchener, E. B., Bretano and Wundt: Empirical and experimental psychology, *Amer. J. of Psychol.*, 1921, *32*, 108-120.

[10] We do not care to have it appear that we are dealing lightly or too naïvely with a question that has for years vexed the historian. He is, apparently, as sensitive to a statement of the problem of history as the psychologist is to a statement of the problem of psychology. This part of the science of history can be traced in the various historical journals.

It has been urged that this method is the only scientific method of dealing with historical data. Static historians point out that interpretation and elaboration in history are as open to objections as is interpretation in any of the sciences. As a matter of fact, the static method does escape the great danger besetting the second conception of history, the conception that history consists mainly of an exegesis or an expounding of discrete facts in the light of some ligating principle or principles. In this respect, history as we look back upon it seems to be an unfolding, an efflorescence, an explication, providing we can use such terms without implying teleology. It is a curious fact that this second sort of history, genetic history, was largely supported by the biological sciences. Within a decade men began to realize that the whole earth and everything in it had a history, a genesis, a growth, an evolution. They realized that only a part of the story had been told by their static description of events. The main problem *had been* to state history "wie es eigentlich gewesen." The genetic point of view made as its quest history "wie es eigentlich geworden."[12] This second type of history, then, involves a high degree of ligation between facts, and the quest of the geneticist is directed primarily toward the principles of ligation, the bonds that give his bare temporal successions a unity and onward-moving significance.

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[11] Quoted by Robinson, S. N., *The new history,* 1912, p. 3.

[12] Robinson, S. N., *op. cit.,* p. 78.

There are, then, at least two ways of regarding history. The historian can be "ultra-scientific"; that is to say, merely descriptive or static, and so put down his facts in orderly temporal succession; or he can enrich and enliven his account by reading into them the culmination of tendencies, the inception of movements, the mental-like stream of pregnant and forward-tending events.

Let us turn now for a moment to psychology. The answer to our query: How are we to write a history of psychology? depends quite as fully upon the meanings of the word psychology as upon those of history. For our present purposes we can distinguish two meanings of the word. In the first sense and at the same time the broadest sense psychology refers, in a general way, to all the events or facts issuing from the existence in the world of minds or of anything mental. That is to say, psychology is a blanket term to cover almost anything from the alleged appearance of dead friends or of the latest achievement of a superior dog to an abstruse discussion of the problem of knowing or of the immortality of the soul. In the second place, psychology may be defined rigidly so as to include only a scientific description of mind, of mental activity, or of mental products. There have arisen, of late, a number of such statements regarding the nature of psychology, statements that definitely exclude a large amount of material popularly known as mental. Moreover, many of these recent descriptions of psychology take the psychologist farther away than ever from certain borderland problems which have in the popular mind formed the central province of psychology. Finally, scientific accounts of mind have eliminated a large number of philosophical problems concerning the nature of mind, of knowing, of the reliability of sense-perception, the origin and significance of the self, and so on.

With these distinctions before us, then, can we state the relevant features of a history of psychology? Our answer must fall under four headings. If history is to be regarded as a *diary* and psychology as the accumulation of common sense and reflective thinking, we shall derive an account considerably at variance with the account issuing from a chronological description of psychology as a science. On the other hand, if history is an interpretation of the diary, a genetic, dynamic account of a growing thing, our psychological history will depend upon our choice of psychology as a general popular discipline or as a specific scientific discipline.

Since much depends upon our choice of a method of writing our history, we shall briefly illustrate the kinds of history falling under each of these conditions. Suppose, for the moment, that history is a diary and that psychology is a general name for the study or observation of anything mental. Our historical chronicle would begin, then, with the first written records we have of man's dealings with mind, either by way of examination or of superstition or by way of reflection on the problem of knowledge. Such a history would take us back to the life and supposed work of Thales and then hasten us through the births and deaths and the date of the principal works of Pythagoras, Heraclitus, the Eleatics, Democritus, Plato and Aristotle, and finally, after many chapters, would give us a breathing spell among the chuch fathers. In these early chapters we should have become acquainted with the numerical relations of the typical Pythagorean, the cosmic and mental elements of Heraclitus or of Empedocles, the sieve-like theory of sense-perception from Democritus, the tripartite world of Plato or the realization of the potential in Aristotle. The chief emphasis in such an account, as is evidenced by most of the text-books on the history of psychology, is the contribution of each individual to a growing body of knowledge regarding mind and the world in which it lives. At least, the emphasis is certainly not on the spirit of the time or the factors in the lives of the men that made their contributions possible.

In writing the chapters on the psychological contributions of the church fathers, some genetic reference must be made, at the least, to Plato and Aristotle. All that the patristic leaders did was in a large measure colored by the writings of Plato and Aristotle. But even so, the other factors that existed in the political and social conditions of the times find no part in a description of the conditions that made patristic psychology what it was. Our daily chronicle would take us through Marcus Aurelius, Tertullian, Origen, Plotinus, St. Augustine, Thomas Aquinas and Duns Scotus. The history of psychology, regarded from the point of view here considered would still mention births and deaths and the principal contributions of each to our knowledge of the functions of the soul and of the intellect and the respective importance of divinity and of the will in the control of conduct. Two hundred fifty years later we should suddenly find ourselves at the inception of a large empirical movement of which Bacon was the first representative and Hobbes and Locke worthy followers. These men formulated doctrines of the nature of mind and of the problem of knowledge that dominated English thought for nearly three centuries, but if the psychologist knows the origin and significance of this movement, it is by way of general history and general literature and not by way of historical research in psychology. In the meantime, under an impetus from Descartes in France and Locke in England, Malebranche crystallizes French thought for a short time and then the record becomes discontinuous, with a number of contending movements of different value. The whole of Germany falls under the spell of Kant and while the chapters of the text run on with the details of the diary, we suddenly find ourselves in the midst of a psychological laboratory with a conception of mind that is scientifically possible and with a method that begins to produce results with amazing rapidity, but with small appreciation of why we have arrived and where we may expect to go. The whole account from this point of view is just a chronological sequence, the noting of the appearance of new movements and of the men responsible for them.

This general situation is similar if we take history as a diary and psychology as a science, save that our history of psychology begins, not with Thales or early Arabian thought, but with some such time as the publication of the *Beiträge zur Theorie der Sinneswahrnehmung* in 1862. The spirit of the account, however, is not different from that just given. The *Grundzüge* is followed by the *Tonpsychologie*, the *Zeitschrift für Völkerpsychologie und Sprachwissenschaft* by the *Völkerpsychologie*, while Hermann's *Handbuch* provides an appropriate sense physiology. The locus of the history is largely in Germany until the late years of the 19th century, when several of Wundt's pupils returned to this country, established their own laboratories and continued the scientific productivity of the German universities.

Now let us turn for a moment to the conception of history as interpretation and to psychology regarded first as accumulated common sense and secondly as science. In this second type of history a new spirit guides the account. We find that men have not only lived and contributed but that they have reflected; they have absorbed from their forefathers and from their contemporaries, and their work is alive with meaning and reference. Thales becomes the spokesman of his day and reflects the type of thought about him. The record from him to Aristotle is not discrete but continuous, and Aristotle is what he is because of the contributions of those who have lived before him. The task of the interpretative psychologist is to discover what there was in the lives of men and in the political and social organization of the time that made the contribution of Aristotle possible. The patristic psychologists are not isolated commentators on the functions of reason but they are rather the reflectors of profound religious, social and political tendencies in the lives of the people. In this history of psychology we do not find ourselves suddenly in the midst of an empirical movement but we find instead a number of tendencies leading for years toward the formulation of just the problems with which Bacon struggled. In the nineteenth century psychology does not come suddenly upon a scientific conception of mind and of psychological method. These are things that have come out of the lives and work of men who were sometimes remote in place and in thought from the events to which they unwittingly contributed.

As is the case in the first type of history, the account is considerably shortened if psychology is considered a science. As a matter of fact, we have now come upon what seems to be a real basis for writing a history of psychology. From this point of view, we no longer need to take up half or three-fourths of our text with an account, either chronological or interpretative, of the problems that are essentially philosophical and not psychological. They become of significance and of interest only in so far as they furnish the basis for the interpretative account that must, for the sake of convenience, begin at some arbitrary date, as for example, the founding of the Leipzig laboratory. In this account of the history of psychology, Meumann and Külpe and Helmholtz and Stumpf and Ach and Messer and others do not stand apart from one another but they are creatures with unique historical backgrounds. The work that they did falls into order and assumes significance only in so far as it represents or reflects tendencies which have their roots in the past, some temporally near and some temporally far away.

In answer to our question, then, we can say that a significant history of psychology can be written with the most of it falling within the last fifty years and but little of it in the preceding twenty centuries. Ebbinghaus's remark that psychology has had a long past and a short history emphasizes the fact that the long past is only a mold in which were cast the essential features of the science. The past, that is, the past prior to some such arbitrary date as we have named, becomes significant only in so far as we need it to interpret the facts and tendencies with which we are now dealing.

If this conception of the history of psychology is acceptable, certain other aspects of the problem become immediately insistent. The histories we have at the present time are but prolegomena to a real history. They are concerned, for the most part, with the pre-psychological facts. It is true that they can be supplemented by the introductory chapters of a good many doctoral theses, but even so we come upon the fact that the science stands in need of much serious historical research, the results of which will form the body of theses instead of brief introductions. We have buried ourselves so deeply in our laboratories and dissipated our energies so prematurely in the fields of psychotechnics that we are, to judge from the tenor of a large part of current periodical literature, losing contact with the real problem of psychology. It is true that psychology has become a complicated discipline. We have said before that it includes a large number of tendencies. The histories that have usually led up to sensationalism have missed altogether the tendencies issuing in functionalism and behaviorism to say nothing of borderland groups of facts that, out of scientific fairness, must be taken into account. The historian of the science must, then, as soon as time reduces and properly valuates our facts, put them together in an organic whole and see what they mean as history. The science needs the impetus to healthy growth that comes from a knowledge of the contributing factors to its existence. One of the chief ways of properly estimating the overnight development of mushroom "psychologies" is to examine critically the kind of soil out of which they have appeared. All the world loves a good problem and a sound method, but neither of these comes from sterile ground. They are generally the results of long incubation or simmering, and their real value to the development of the discipine as a whole falls under the scrutiny of the historian who can place them in proper perspective.

The historian of the science of psychology stands in a peculiar relation to his fellow historians. He is dealing with material that is more like mind in its fluent character than any other process. The nature of mind is such that it must be viewed in the light of its own organization and function. The psychologist, by virtue of his knowledge of the subject-matter with which he deals, is peculiarly fitted to exhibit the conditions under which points of view develop and the ways in which our present achievements are related to the past. Mind in its own development is cumulative in a peculiar sense, and as the historian of mind views the facts of his science he finds that they too are, as mental monuments or products of mind, also cumulative. By virtue of his training and his knowledge, the psychologist is committed to the type of historical research we are urging. He has stripped his science of its meaning if he contents himself with a chronology. He is bound to regard the past as a promise of the future and the present as the natural outgrowth of the past.

It appears, then, from our discussion thus far that a history of psychology should consist of an interpretative account of psychology taken as a science. This makes the historical account short in the time covered but long in the developments included. We have found also that the proper valuation of the field as it is rests first of all upon sound historical research, and that the psychologist was peculiarly fitted to be a historian.

We have now to ask what should be the central factors in a history of psychology? About what central theme should the account be written? Too often histories are colored by the desire to show that events are leading naturally to some favored system of interpretation of fact or are useful for purposes of propaganda. But, viewing the science in the large, is there a central theme about which the history can be written, a theme which will not at the same time be an excuse for propaganda. There are a number of possibilities appearing at once. Psychology has depended largely upon the formulation of its methods. But it has also developed a scientific statement of its problem and it has discovered certain vital relations with other scientific disciplines. Let us propose, however, in order to bring the matter to a focus, that the history of psychology should have as its central theme the tracing of the stages in the development of a scientific conception of mind. Method and problem have waited upon a conception of what the subject-matter of psychology really is. If the history of psychology means anything, it means that all that men have done or are now doing in the field rests essentially on this one problem, *viz.,* what is mind? This kind of difficulty did not materially hinder the development of the physical and the biological sciences; although they had to outgrow the belief that life was a manifestation of some immaterial force or power and that events in the physical world were controlled, not by natural laws, but by resident spirits of one kind and another. The development of a scientific conception of mind, however, has been a serious problem. Indeed, it appears to be one of the most serious problems with which the history of psychology has to deal. If mind is a form of energy, then our method and the statement of our problem are to a certain extent already established. If mind is the manifestation of the soul in the body, other methods and other problems are presupposed.

Now, as a matter of fact, two generations of psychologists have been working on an empirical level with just such a concept. As a result of centuries of reflection, and by virtue of inheritances from the related sciences, psychology turns out to be neither the study of the activities of a soul nor the study of a subtle kind of energy. On the other hand, the science consists of an accumulating series of observations directed toward mental experiences. The laboratory has gone to work on the assumption that if it takes a small bit of human experience and repeats it over and over again under conditions that are carefully controlled and undertakes to reduce the experience to its smallest constituents, it has made a scientific description of the event. When all such experiences are thus scrutinized from the point of view of composition, of organization, and of function, and the facts are then moulded into a system, the task of the psychologist is done. His labors have been fruitful beyond his early anticipation.

It is obvious, then, that a history of the *science* of psychology must be written on the empirical level which the discipline has attained. A history of the functions of the soul or of the problem of knowledge or of the nature of the ego is no longer adequate to the mature dignity of the science. A substantial and adequate history will, according to our analysis, consist, in part, of a genetic account of the development of the scientific concept of mind, and, in part, of a survey of the products of the laboratory and the growth of empirically organized systems of psychology.

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A PRELIMINARY STUDY OF THE EMOTIONS[1]

By C. A. Ruckmick

For several years we have made an attempt to investigate the emotions and, to some extent, the affective processes in general in accordance with the experimental procedure followed in connection with other processes. It has long been recognized that an empirical study of the affective dispositions was bound to meet with almost insuperable obstacles. For one thing, it was difficult to plan a series of experiments that would keep the observers naïve. If an observer has been once or twice tricked into an emotion, he will not only guard against a future repetition but he may actively set himself against the arousal or,—what amounts to the same thing,—he will not meet the attempt seriously. In another respect difficulties appear on the side of the process itself. If the charges of Herbart and of some of his predecessors concerning the distortion of the process under investigation have any weight, it is certain that they will have special significance in connection with the emotional experiences of the human mind.

It has been a common practice to attack the emotional life either from the side of its physiological expression or through its effects on other mental processes. A considerable amount of material is to be found in the literature concerning the physiological effects in the psychophysical organism, and latterly emphasis has been placed upon the secretions of the ductless glands. So far as we are aware, there has been very little work done

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[1] The author is grateful first of all to Miss Merle Turner who posed for the photographs and eagerly took part in the long process of making, selecting, and often discarding the expressions obtained. Various divisions of the composite study were assigned to students who elected a major course in the Department of Psychology. Among them are Miss Harriet Anderson, Miss Marion Louise Smith, Miss Zeniar Kizer, and Miss Esther E. Kinsey. To this list ought to be added a long roll of observers. To all of these the author wishes hereby to give credit for work faithfully undertaken and done.

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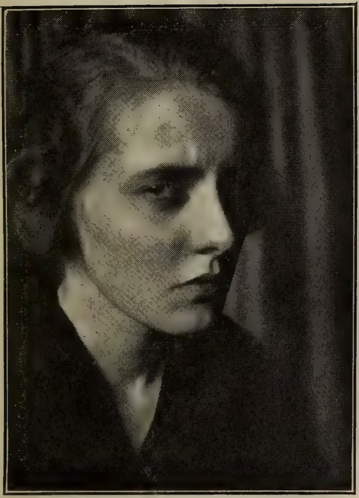

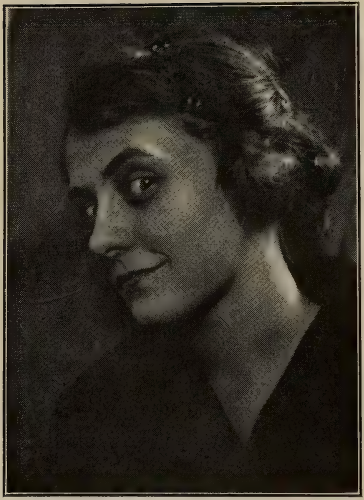

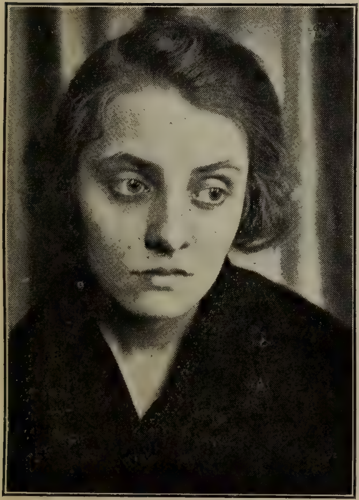

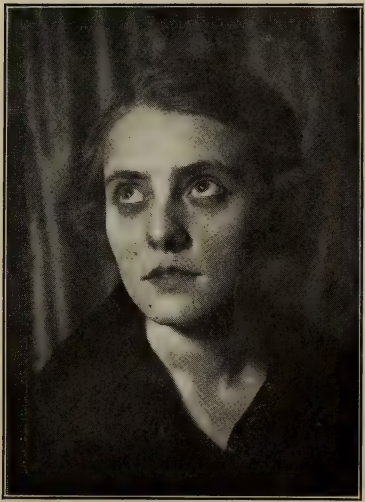

PLATE I

on the facial expression of emotion. The studies of Langfeld at the Harvard laboratories and some previous investigations of Feleky have brought once more to our attention what can be done with the human face.

I

The collections[2] of facial expressions so far published and available for general use are made up of line drawings of a heavily bearded face that was obviously "touched up" by some artist. Outside of the Columbia studies later to be mentioned, little or nothing had been done with the female face. We were curious, for example, to see what range of expression we could obtain without such accentuating accessories as a moustache and beard. We therefore arranged for a series of sittings with one of the talented women students in the University who had had considerable training in dramatic performances. The plan consisted in drawing up a list of expressions that we desired to photograph and in selecting for each day three or four of these for practice. During her spare time in the morning, the student would practice the expression before a mirror, frequently with the assistance of some classical quotation which she had recalled in connection with this particular emotion. She would then come at an appointed hour in the afternoon to one of the dark rooms in the laboratory which was illuminated by a high candle-power incandescent light. The camera was placed within three or four feet of the face and to one side, as close as possible to the camera, a mirror was hung in which she could observe her expression until the desired exposure was made. The experimenter, too, frequently criticized the expression, and sometimes, when the attempt proved to be unsuccessful, deferred that particular expression for a more opportune time. There was, of course, a suitable neutral background and the student was uniformly draped in black velvet so that all but the face fell into the background.

At this point it must be remarked that the expression of the emotion was necessarily confined to the face. The voice, for instance, played absolutely no part in the depiction of the emotion. In one or two instances only were the hands or other portions of the body permitted to take part and then merely to assist the portrayer in her efforts to express her emotion. Since this part of the body was not photographed, it could not enter into the interpretation of the expression.

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[2] Rudolph, H., *Der Ausdruck der Gemütsbewegungen des Menschen,* (2 vols.), Dresden, 1903.

The exposure was made for some five seconds and then both the student and the photographer repaired to the dark room to see whether the negative was satisfactory. If unsuccessful, that particular expression was repeated until it had been properly reproduced. Thirty-four negatives were retained when the process was completed. Examples of these expressions are shown in Plates I and II.

II

Our first attempts lay in the direction of determining how successfully the emotions were portrayed as judged from the interpretations independently made by over a score of observers. Some of these observers were left to their own choice of names, after being instructed to be as concise as possible. Other observers were given a condensed list of names from which to choose the corresponding photographic expression of the emotion, much in the same fashion as was done in the study of emotion at the Columbia laboratories.[3] The series of thirty-four photographs were submitted to each of the four observers with the following instructions:

"You will be shown the photograph of a face. Please note first what meaning you read into the face, and second, any change in your own affective reaction as a result of viewing the picture."

Each observer was asked at the beginning of the series to describe his emotional state. After viewing the picture, he was further instructed to write down (1) the name of a brief description of the emotion portrayed in the photograph and (2) a descriptive commentary upon his own inspection and interpretation of the picture.

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[3] Feleky, A. M., Expression of emotions, *Psychol. Rev.*, 1914, xxi, 33-41.

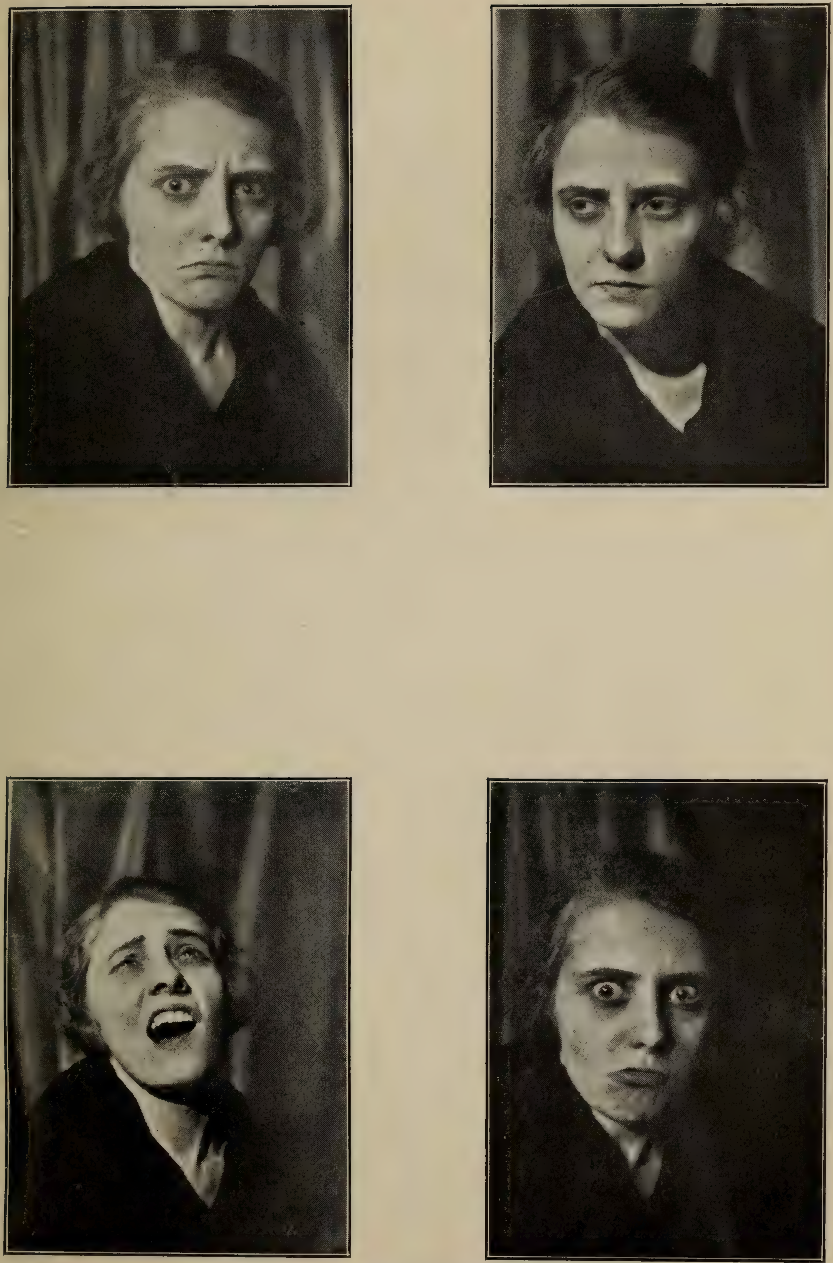

Plate II

The attached list shows the variety of expressions used to designate the interpretation of the photograph. Some allowance must be made for inadequacy of verbal expression, as when an observer gropes about to find a word that will carry his meaning. Some emotional expressions, especially when the emotion becomes intellectualized, give a much less uniform response on the part of the observer than others, as will be seen by comparing, for example (see accompanying list), No. 14 or No. 20 with No. 21 or No. 30. As a rule. the "primary" emotions, as love and hate, joy and sorrow, are much more uniformly interpreted than the "secondary" ones, like repulsiveness, surprise, distrust and defiance.

In all these cases, the observers were asked to set down their interpretations without suggestions from the experimenter. The problem that suggested itself was the question regarding the rôle of the several facial features in suggesting the interpretation. Our photographs were so taken, as we have before noted, that the expression was confined to the face. The point now raised was: do the eyes furnish a better cue than the mouth, or the lines about the nose? In a preliminary study with some fifteen copies from the Rudolph collection, the face was divided up into three sections showing only the eyes in one case, the nose and lines about the nose in another, and the mouth in the third. In still another series the face was divided into upper and lower half. In this preliminary experiment it was found that next to the whole face the lower half of the face gave the best cues for interpretation; then in order came the eyes, the lower half, the mouth, and finally the nose and the lines about the nose. This series was repeated with our collection of thirty-five portraits with the same results. In order to avoid the observer's memory of the picture giving him the necessary suggestions, the series was so arranged that in each series of ten presentations each day one-half of the number were always new for that week. The results indicated, with only a few exceptions, that memory played comparatively little part in the interpretation of the partially covered face.

III

In still another experiment we attempted to show, on the basis of introspective evidence, what were the mental processes which conveyed the meaning of the portrait and to what extent there were individual differences in this procedure. We had casually noticed before, in previous studies, that some observers would visualize the entire person whose portrait was shown and ideationally integrate the position of the hands, posture of the body, and occasionally relevant objects about the room; others could hear the words spoken; still others would call up memory pictures of their own similar experiences; and some would take the picture quite passively as a picture without going interpretatively behind it. There seemed to be in the last case comparatively little elaboration. The author has found the same difference in individuals attending cinematographic performances.

To illustrate the dramatization of these portraits and also the individual differences in the manner of their interpretation, a few statements from the observers will be quoted:

"She has been crying, but when another person enters the room she becomes defiant. She refuses to be dictated to. Hitherto she has been quiet but on the entrance of the second person she calls out angrily."

"The rather stary eyes give the idea of interest but of a person who is ill and has not physical strength or else is tired. I remember feeling the same way the subject looked when I have been tired."

"Someone for whom the girl feels responsible has gotten into difficulties and the subject of the picture is more or less terrified and searching anxiously for a solution of the problem."

"I noticed that my own eyes seemed to hurt when I looked at the picture and I felt a sagging of the muscles above the mouth."

"I feel a contraction of the muscles in the throat and tongue. My teeth are set and there is a feeling of strain."

"Terribly unpleasant visual perception of a drunken man and his children in the room."

IV

It appeared that the mood of the observer changing from day to day had some effect on the interpretation of the face. We

INTERPRETATIONS BY OBSERVERS

	Expression Intended	(Obs.) A	B	C	D	E	F	G	H	I	J
1	Bodily pain	Pain	Pain	Bodily distress	Suffering	Anguish	Pain	Pain	Bodily anguish	Despair	Pain
2	Resentment	Fear	Sadness	Surprise, resentment	Retrospection	Given up hope	Thought	Endurance	Hopeless suffering	Haughtiness	Despair
3	Scorn	Scorn	Contempt	Contempt, disdain	Disgust	Sneering	Scorn	Doubt	Disgusted scorn	Contempt	Disgust
4	Sulkiness	Disappointment	Dejection	Sullen, rebellion	Sulkiness	Moroseness	Sulky	Disappointment	Reproving	Poverty	Forlornness
5	Thoughtfulness	Contemplation	Thought	Angry resistance	Memories	Reproving	Attention	Interest	Thoughtfulness	Thinking	Defiant fear
6	Grief	Pleading	As one persecuted	Sorrow, hope of relief	Expectancy	Poverty-stricken	Pleading	Sight of pain	Dejected anxiety	Questioning	Plea for mercy
7	Amusement	Happiness	Amused	Humor	Welcome	Happiness	Contentment	Amusement	Cheerful, good humor	Happy	Care-free
8	Laughter	Joy	?	Gay laughter	Raillery	Joyousness	Merry	Enjoyment	Heartfelt joy	Amused	Joyousness
9	Interested amusement	Amused interest	?	Interested inquiry	Interest	Admiration	Happy	Entertainment	Snippy pleasantry	Expectant	Amused interest
10	Vindictive rage	Repulsion, anger	Anger	Gross fun	Fright	Insane, drugged	Hate	Terror	Maniacal fear	Contemptible	Evil
11	Surprise	Pleasant surprise	Surprise	Surprise, pleasant	Wonder	Surprise	Surprise	Enlightenment	Surprise and joy	Surprise	Surprise
12	Extreme anger	Disappointment	Discouraged	Surprise, apprehension	Apprehension	Intense thought	Dismay	Fright	Dread	Disappointed	Discouraged fear
13	Tearful sorrow	Sorrow	Disillusion	Stupefied grief	Dejection	Grief	Sorrow	Grief	Sorrow	Sorrowful	Grief
14	Terror (incl. fear)	Astonishment	Fear	Horror	Startled	Sudden fear	Astonishment	Horror	Fright	Startled	Fright
15	Horror (incl. suspense)	Pained surprise	Fear	Apprehension, painful sight	Agitation	Torture	Shock	Suspense	Bodily pain	Hurt	Horror
16	Hopelessness	Wistful	?	Rueful meditation	Sadness	Resigned-to-fate	Wistful	Pity	Longing	Dreaming	Pity
17	Worship	Inspired	?	Mild, passive elation	Hope	Spiritual	Inspiration	Awe	Peaceful contemplation	Adoration	Adoration
18	Apprehending an idea	Amused questioning	?	Suspended anguish	Interest	Oh!	Questioning	Inspiration	Quizzical contemplation	Whimsical	Cynical interest
19	Interested observation	Love	?	Pleasing observation	Attention	Interest	Interest	Convinced	Interested observation	Pleasant	Superiority
20	Anger	Angered fright	Hate	Anger	Vindictiveness	Anger	Anger	Disagreement	Excited	Angry	Hate
21	Distrustful hate	Distrust	Mean	Critical disapproval	Sulkiness	Peevishness	Distrust	Dissatisfaction	Earnest critical superiority	Scorn	Rebellion
22	Begging entreaty	Pleading	?	Sentimental admiration	Mild resignation	Assumed happiness	Pleading	Wistful	Pathetic, appealing	Slight pleading	Don't care
23	Distrust	Suspicion	Distrust	Critical reserve	Doubt	Distrust	Doubtful	Suspicion	Keen, questioning	Revengeful	Sneaking deceit
24	Dumb surprise	Wonder	Incredulous	Wonder and fascination	Surprise	Disputing air	Wonder	Revelation	Surprised fear	Astonishment	Astonishment
25	Haughtiness	Haughtiness	Firm	Rebuke	Haughtiness	Haughtiness	Haughty	Defiance	Superiority	Haughty	Pride
26	Defiance	Angry defiance	Defiant	Repressed inquiry	Reproach	Stubborness	Defiant	Challenge	Commandeerng snobbishness	Indignant	Defiance
27	Curiosity	Interest	?	Rapturous contemplation	Faith	Look of inquiry	Attention	Convincement	Interested, non-hearted	Interested	Love
28	Sympathy	Sympathy	?	Mild, wistful rebuke	Indifference	Pleading	Sympathy	Wonderment	Hurt surprise	Coaxing	Pleading
29	Screaming pain	Anguish	?	Agony	Hysteria	Terrible suffering	Anguish	Past endurance	Great bodily anguish	Pain	Fear and pain
30	Contemptuous smile	Cynical humor	?	Mischievous	Amusement and contempt	Worldliness	Sarcastic	Mild, forced interest	Foolish, simple-minded gaiety	Leering	Sneering
31	Suffering, not bodily, pain	Ill, faint	Surprise	Dull, pain	Pain	Tired, pain	Intense pain	Agony	Hopeless pain	Wounded	Pain
32	Tearful laughter	Sympathetic love	?	Mild gaiety	Reconciliation	Content	Love	Relief	"After sorrow comes joy"	Yearning	Frivolous
33	Violent laughter	Mirth	?	Explosive enjoyment	Amusement	Joking	Mirth	Happiness	Vivacious youthfulness	Laughing	Joy
34	Shocked surprise	Surprise	Surprise	Consternation	Horrified	Astonishment	Awe	Awe	?	?	?
35	Skeptical smile										

undertook therefore another series of investigations using four observers of markedly different temperaments, depending in some instances on daily changes in their moods and in other instances contriving means, either by showing unusual pictures or by making various statements to them, to change from time to time their affective disposition while looking at the pictures. For instance, photographs of starving Viennese children were available at the time. These were shown quite suddenly to observers, and the effect on their subsequent judgment of the facial expressions was noted as compared with normal series. Introspections revealed whether or not the desired effect was actually experienced. On another occasion, the observer would be scolded in the presence of others, and sometimes by the instructor, for being habitually late to his appointments or for failing to hand in required work.

Series were obtained also in order to ascertain variations in the interpretations, made from day to day, that were due to other than emotional disturbances. Our results show, in agreement with Langfeld,[4] that individuals vary not only with regard to suggestions from without but also in accordance with emotional experiences often concealed from another in interpreting the same facial expression on different occasions. Three of our observers allowed these experiences to color their judgment; one observer was apparently immune to all influences even of a highly emotional nature by way of changing his judgment. Often the change in interpretation is slight, as, for instance "pain" on one occasion, and "agony" on the other, or "amazement" at one time and "horror" at another.

In going over our detailed accounts, it is noticeable that fewer changes are made under suggestion in those emotions that are usually classed as "primary"; while more radical changes of judgment occur in those that are not so easily named.

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[4] Langfeld, H. S., Judgments of emotions from facial expressions, *J. of Abnormal Psychol.*, 1918, xiii, 172-184; Judgment of facial expression and suggestion, *Psychol. Rev.*, 1918, xxv, 448-494.

A COMMENT UPON THE PSYCHOLOGY OF THE AUDIENCE

By Coleman R. Griffith

A group of university students registered in a given course and assembled for the lecture-hour displays in a unique manner the typical characteristics of an audience of the polarized sort.[1] The chief social relations obtaining between the speaker and such an audience are of the all-to-one and one-to-all types.[2] The auditors, so far as general dispositions are concerned, are in a receptive, expectant mood, with a homogeneity of interest which serves to carry the lecture-topic at a fairly high level of attention. Such an audience is characterized by a sophisticated attitude that eliminates the distress and disturbance of unfamiliarity; by a general cortical set which determines in advance of the lecture the general apprehensive and affective patterns; by a preliminary tuning induced by familiar faces, significant apparatus, drawings, charts and so on; and finally, by associative tendencies which focus the attention of the group upon a single topic. It is under these conditions that the all-to-one and one-to-all relations develop; but it is not at all evident that the bonds from every part of an audience are equally effective in drawing individual members into social contact with the speaker. There is no reason to suppose that, in the all-to-one relations, an individual in the periphery of the group is as definitely polarized as individuals nearer the speaker. It might, on the other hand, be conjectured that such an individual was much less an integral part of the group, for the perceptual and affective patterns from nearby neighbors must certainly contribute to the maintenance of the all-to-one relations. Frequently an outlying member of a group does not have just these clues to social integration and the lack may, as has been recently suggested,[3] make a difference in the level of performance of such members of the group.

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[1] See Bentley, M., A preface to social psychology, *Psychol. Monog.*, 1916, xcii, (vol. *21*, No. 4), 20ff; Woolbert, C. H., The audience, *ibid.*, pp. 37-54.

[2] Woolbert, C. H., *op. cit.*, pp. 44ff.

On the other hand, it is a common complaint among students who sit at the rear of large lecture-rooms that they can neither hear the lecturer nor see his demonstrations. If this complaint is well founded, the fact ought to be reflected in the accomplishment of such students. Now academic grades are a measure of accomplishment in both of the situations we have mentioned, and it follows that a critical analysis of the distribution of such grades in lecture-halls ought to betray differences in performance that cannot be attributed to differences, either in mental ability or in physical well-being.[4]

If it can be determined, other things being constant, that the performance of students at the rear of a large room is actually less than the performance of those at or near the front, the students are partially justified in their complaint. We are not here interested in the complaint, however; instead, our inquiry touches the question as to whether a difference does actually exist between grades in different parts of a room, and if it does, for what reasons.

The answer to our query was sought by a tabulation, according to the seat-numbers in five large audience-rooms at the University of Illinois, of the grades of students registered in several large courses. In every case the students were alphabetically seated. Mid-semestral, class, laboratory and final examination grades, as well as the final semestral grades, were considered. Courses were sought which, at the one extreme, were conducted with the minimal amount of lecturing and a maximal amount of quiz and laboratory, and, at the other extreme, were conducted with a maximal amount of lectures and a minimal amount of quiz and laboratory work.

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[3] For example, Allport (Allport, F. H., The influence of the group upon association and thought, *J. of Exper. Psychol.*, 1920, *3*, 159-182) has shown that performance in association and thought depends to a certain extent upon social factors.

[4] Recent experimental education has, as we all know, been deeply concerned with differences of performance which parallel differences of mental ability. A great deal of attention has been given also to the influence of health and of other physical factors on the degree of performance. We are not here concerned with intelligence ratings, however, but are assuming that mental ability, physical well-being, and similar factors are evenly distributed, under the conditions which we have chosen, throughout a given auditorium.

Now the tabulation of something like twenty thousand such

TABLE I

Showing 1st and 2nd Quiz grades, final examination grade, and final semestral grade of all students in Course——, 2nd semester, 1916-1917.

ROWS	GRADES	THE OCCUPIED SEATS										AVER.	M.V.	AVER. (ALL GRDS.)	AV. OF M.V.
8	1st Quiz		18	80			60			51		52.2	17.7	60.1	12.6
	2nd Quiz		50	77			60			65		63.0	8.0		
	Final Ex.		53	81			79			50		65.7	14.2		
	Final		60	78			75			50		65.7	10.7		
7	1st Quiz	77	44	94	36	71	75	48	69	32	79	62.5	18.1	75.6	12.0
	2nd Quiz	83	90	98	51	91	76	75	74	55	93	78.6	12.4		
	Final Ex.	85	79	95	85	99	84	73	84	39	86	80.9	10.3		
	Final	86	81	91	71	90	87	76	78	60	86	80.6	7.3		
6	1st Quiz	40		69	61	50	93	84	79	42	71	65.4	15.6	76.8	10.0
	2nd Quiz	66		90	73	83	95	85	84	64	75	79.4	8.8		
	Final Ex.	80		89	81	61	98	81	96	83	80	83.2	8.2		
	Final	65		80	78	72	92	83	87	71	82	79.0	7.4		
5	1st Quiz	69	67	93		69	44		55	92		69.8	12.9	75.9	8.1
	2nd Quiz	74	76	84		71	51		78	89		74.7	8.0		
	Final Ex.	77	83	88		80	80		64	89		80.1	5.6		
	Final	75	80	87		77	70		73	91		79.0	6.0		
4	1st Quiz	65	66	95	37	82	69	80		61	76	70.1	9.5	78.8	7.1
	2nd Quiz	70	76	84	59	76	75	95		70	99	78.2	8.1		
	Final Ex.	81	90	93	77	85	86	93		73	93	85.7	6.1		
	Final	80	82	86	72	82	80	98		73	90	82.5	5.7		
3	1st Quiz	72	94	63	60	70	69			89	56	71.6	10.7	76.0	6.3
	2nd Quiz	59	80	77	77	82	80			80	71	75.7	5.4		
	Final Ex.	73	85	87	85	79	68			73	90	80.0	6.7		
	Final	73	78	80	74	80	75			75	78	76.6	2.4		
2	1st Quiz	83	35	80	56	60	89	88	62	66	66	68.5	13.2	74.0	9.5
	2nd Quiz	68	55	55	61	60	96	71	63	88	60	67.7	11.5		
	Final Ex.	70	58	79	85	88	94	90	85	90	85	82.4	7.9		
	Final	75	65	78	74	71	92	84	77	85	73	77.4	5.3		
1	1st Quiz	81	88	62	69	86	95			30	21	66.5	21.6	72.3	12.8
	2nd Quiz	76	67	58	69	74	98			52	46	67.5	10.5		
	Final Ex.	96	86	71	54	76	91			85	73	79.0	10.5		
	Final	86	86	70	65	77	93			71	62	76.2	8.6		

SPEAKER'S PLATFORM

grades does make it evident that, with the significant exceptions to be noted below, the accomplishment of students in the front rows is from 3% to 8% less than that of students in the middle of the room. The results indicate, further, that there is a still more marked difference,—approximately 10%,—between the grades in the middle of the room and the grades found in one or two rows at the rear. We shall appeal by way of illustration, to a lecture-group which bears out these facts in a distinctive manner. In Table I are put down the actual grades received by students in a course in ——— given during the first semester of 1916-17. Two preliminary quiz grades, the final examination grade, and the final grade for the course are included. The averages show clearly enough that the individuals occupying front seats have lower grades than those in the second and third rows, the difference being greatest between the first and fourth rows. In like manner, the individuals at the back of the room (row 8) are 18.7% lower than the average of the fourth row.

This striking difference varies during the course of the semester, as can be discerned in Table II, which is a further analysis of Table I. For example, the average grades at the time of the first written quiz decrease from the third row in the following manner: 71.6, 70.1, 69.8, 65.4, 62.5, 62.2, giving a maximal difference of 19.4% It will be observed that 10.3% of this difference falls between the seventh and eighth rows, so that the seventh row is 9.1% lower than the third row. As the semester proceeds, however, the individuals in the sixth and seventh rows improve with respect to the central group, with the result that, at the time of the final examination, the average from the sev-

TABLE II

Row	Av. 1st Quiz	Av. 2nd Quiz	Av. Final Exam.	Av. Sem. Grade
8	52.2	63.0	65.7	65.7
7	62.5	78.6	80.9	80.6
6	65.4	79.4	83.2	79.0
5	69.8	74.7	80.1	79.0
4	70.1	78.2	85.7	82.5
3	71.6	75.7	80.0	76.6
2	68.5	67.7	82.4	77.4
1	66.5	67.5	79.0	76.2

enth row is but 4.9% lower than the highest average, which falls at the fourth row. It is obvious that some factor, partly overcome during the semester, serves to act as a handicap to the individuals at the back of the room. The large initial difference between the seventh and eighth rows and its persistence during the semester is characteristic of many of our tabulations, and the cause is to be sought, apparently, in some disadvantageous condition which especially hampers these students in the eighth row for the entire semester. Occasionally, however, the back row does recover and then no appreciable difference in distribution is observable in the final grades. That there is still a difference in the degree of accomplishment within the group at large, however, may be seen from the fact (cf. Table III) that ¼ more students in the front than in the middle receive grades below 70%, while over twice as many in the back rows are graded below 70%. There is a tendency, therefore, more marked at first, for high grades to be grouped in the middle of the room. The significance of this distribution is made clearer by the fact that, at the front of the room, a little over a quarter of the students advance in their grades as the semester goes on, while, at the back of the room, more than one-half of the grades improve during the semester. In other words, the poor accomplishment of students at the front and at the back, at the time of the first written quiz, seems to act as an incentive to greater efforts and the improvement that is shown during the semester is not at all equaled by the improvement of students in the middle group, for whom there is, presumably, no such incentive.

TABLE III

Row	Below 40	40-49	50-59	60-69	70-79	80-89	90-99	% Below 70	% Above 70
8	1	0	5	4	3	2	0	66	34
7	3	2	2	2	13	9	9	23	77
6	0	2	1	6	7	14	6	25	75
5	0	1	2	4	9	8	4	25	75
4	1	0	1	4	10	12	8	17	83
3	0	0	2	4	14	10	2	19	81
2	1	0	3	10	9	11	5	36	64
1	2	1	3	6	7	7	5	39	61

The large difference between grades from the middle and from the front and rear sections of a room, at the time of the first written quiz, with the somewhat smaller difference at the end of the course, is more significant than at first appears. It has been found, for example, that the difference is more pronounced in courses where relatively greater emphasis is placed on the material given in lectures. Students who are quizzed but once a week on two lectures show about twice as great a difference as appears where one lecture furnishes material for one or more quizzes and one or more laboratory hours. Furthermore, an informal lecture method (adopted most frequently with small groups) shows on the average a still smaller degree of difference, the variation in this case being but three or four per cent. That is to say, there is not here so large a difference between the number of students who receive exceptionally low or high grades in various parts of the room.

There are other peculiarities to be noticed. If a group of students is removed from the main body by an aisle or by a group of empty seats, their grades are on the average 5-10% lower than the grades of students sitting in the main section. For example, in Lecture Group C an aisle running parallel with the platform separated about fifty students from the main group of approximately 400. The final average of the students just in front of the aisle and belonging to the main group was 68.0. The average of the 50 students just behind the aisle was 61.0. In Lecture Group D the two aisles ran at right angles to the platform. The main body of students sat in the area directly in front of the lecture platform. Some 25 students sat across the aisle to the right and an equal number across the aisle to the left. The average performance of the central group was 80.3 and of the lateral groups, 76.0. In this later case the difference is materially increased if the grades of students at the rear of the rooms are omitted. Again, within the range of the rooms here included, which seat from 70 to 500 students, the difference does not seem,—as one might expect,—to be a function of the absolute size of the room. Again, the fact that practically all of our groups have shown the decrease in question indicates that the difference is not essentially dependent on the lecturer; although we have seen that an informal method with small groups may result in a smaller difference. And, finally, an area of low grades at the rear of a small group in a large lecture room may coincide with the area of maximal grades for a large group in the same room. That is to say, the region of low grades so moves with the periphery of an audience as that low (peripheral grades of a small group actually fall in the very same seats as do the high (central) grades of a large group.[5] This fact can be seen to advantage in Figure I, where the curves represent the average grades of different rows in classes occupying seven, eight, and ten rows.

To summarize: The statistical treatment of student's grades suggests that there is an appreciable difference between the work and the accomplishment of individuals who occupy a central position in a lecture room and the work and accomplishment of those who occupy the outlying sections. This difference, which is greater at the time of the first quiz than at a later time, is also influenced by a natural division between groups, such as an aisle or a few empty seats or by pillars, and by the degree in which the course is dependent on lectures. Frequent small sectional and laboratory meetings tend to reduce the difference, which appars to be dependent upon the position of the student with reference to the rest of the group.

Now there are three factors directly related to the distance between auditor and speaker which might tend, in a large group, to bring about the differences of performance which we have found. In the first place, there is a difference in the perceptual

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[5] In all the averages we have given, the *m. v.* is, as a rule, nearly if not quite as large as the differences we have cited as existing between the center and the periphery of a room. It must be remembered, however, that the one factor of differences in mental ability accounts for a large part of the *m. v.* When proper allowance for this factor is made by discovering the performance of the same or similar students in groups of thirty or less, the *m. v.* of the middle group is negligible; but at the front and especially at the rear the *m. v.* is still large and must be accounted for. We are inclined to urge that the large *m. v.* in these regions is not an indication of unreliability or of inadequate sampling but that it is further evidence that the individuals in these areas are working under some kind of a handicap. A few overcome the handicap and obtain average or exceptional grades, while the remainder succumb and receive exceptionally low grades.

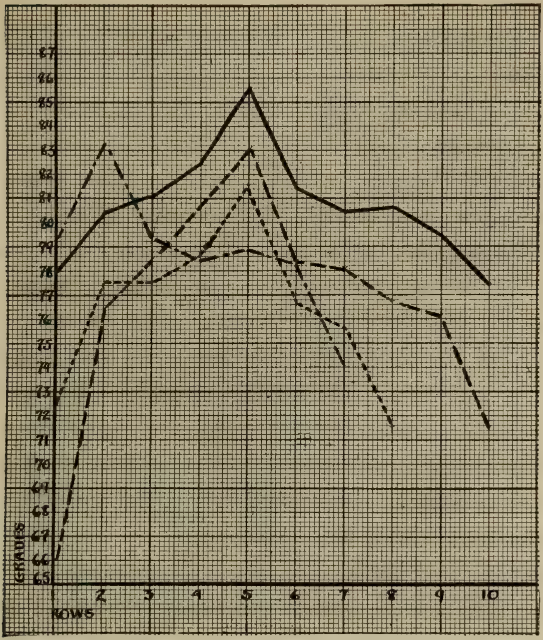

FIG. I.—Distribution of grades by rows in four lecture groups in different subjects but meeting in the same room.

factors dependent upon the distance of the student from the lecture-desk. It is apparent, of course, that while the acoustic properties of lecture-halls widely differ, in any one of them students sitting moderately near a lecturer have better opportunities for hearing. The same is true of visual factors, for frequently the success of a lecture depends largely upon demonstrations involving small objects and delicate manipulations, upon charts having inadequate size or illumination, and upon the facial expression and movements of the speaker. Moreover, lecturers differ in their ability to enunciate clearly as well as in the intensity and in the carrying power of their voices.

In the second place, there is a difference in the direction of attention resulting from the distance of the student from the lecture-desk. Our results suggest that there are three zones in which the direction of attention changes. We have found, for example, that, on the whole, individuals sitting very near the lecturer have lower averages than those a little further removed. In these cases, it is not at all impossible that the attention of the student is taken up with a variety of irrelevant details. That is to say, there are facial changes in the speaker, idiosyncrasies of clothing and of gesture, and a host of other items that thrust themselves upon the attention of those near at hand. Unessential details of the apparatus are also a source of distraction. Further back, these details are lost and here, curiously enough, the highest averages are generally to be found. This group is in the best position for attention to the meaning and the sequence of the discourse. At the rear, still another situation appears. We have already indicated that here the perceptual processes may be at fault. This undoubtedly leads to a frequent shifting of attention from the lecture. It seems, then, that there may be an optimal distance at which the perceptual and attentive factors are the very best. In addition to these facts, lecturers differ in the amount of perceptual detail presented which is apt to draw attention. Lecture-rooms differ, also, in the distance between the lecture platform and the first row of seats. Furthermore, some lecture sections make a practice of leaving two or three vacant rows at the front. All of these factors would bear a direct relation to the steadiness and the direction of the attention elicited.

There is still another factor which may account for the discrepancy of performance between groups near to and remote from the lecturer. This factor is a result of the kind of instruction which students directly or indirectly give themselves and it is doubtless dependent, in large measure, upon the factors which we have already discussed. Among students sitting near a lecturer, this instruction may take either of two forms. The student may, in a large course, congratulate himself on having a fortunate location and so make it a means of getting all that goes on; or he may be subject to a negative instruction expressed in the words: "I am near the front. It will be so easy to get everything that I need not exert myself." As regards the group in the center, we find that it is again in an optimal position; these individuals are not near enough to be cognizant of everything, relevant and irrelevant, that is going on; and neither are they so far away as to be in doubt. At the extreme rear, however, there are, again, two kinds of instruction. Some individuals, appreciating the fact that they are working under a handicap, realize that they must give special attention, if they are to maintain their standard of work. The statistical fact that there are about as many high grades at the rear as there are low grades suggests not only that perceptual and attentional factors need not be determinative; but that this kind of instruction plays a major part, especially after the first quiz, when a low grade adds an incentive to improvement. On the other hand, there is a group of individuals who take the negative instruction that since they have been placed where they cannot well see or hear they will give up the effort. Once again, the statistical fact that the low averages in the rear are due not so much to a general lowering of the grades as to a larger number of excessively low grades suggests that this instruction is too often taken.[6]

But when we have made due allowance for such physical factors as distance and intervening objects, factors which directly bear upon the adequacy of perception and the degree and steadiness of attention, there still remains a difference in performance to be accounted for. The fact that the low grades of a small group may exactly coincide in place with the high grades of a large group in the same lecture-room suggests that there is a factor directly dependent upon the group itself. Now it is a commonplace observation that individuals in the periphery of a large crowd are apt to be restless and inattentive to whatever may be attracting the interest of the main group. That is to say, physical compactness and the interests and activities of a group polarized toward the speaker tend to knit together the main body of an audience in a way that is not possible for individuals seated near the borders of the group. That this factor of social integration plays a large part is indicated by the effect of aisles or other marks of separation, by the effect of a dialectic or informal mode of address, by the decrease in the differences between the optimal region and the peripheral regions as the semester goes on and as social integration becomes presumably greater, and finally, by the fact that relatively low grades always come from the periphery of a group, no matter how small or how large,—within the limits of the audiences here investigated,—the lecture group may be.

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[6] For example, note the following quotations taken directly from students. When asked what the trouble was, one replied: "Well, I'll tell you. It was just like this. In all my other courses I sit near the rear and I have to pay attention in order to know what's going on. But in this course I was right up at the front, and it seemed a cinch so I didn't care much what notes I took." Or, again, "Well, one thing, I think, is this. They put me away back in the rear. I couldn't see or hear very well and I just lost interest."

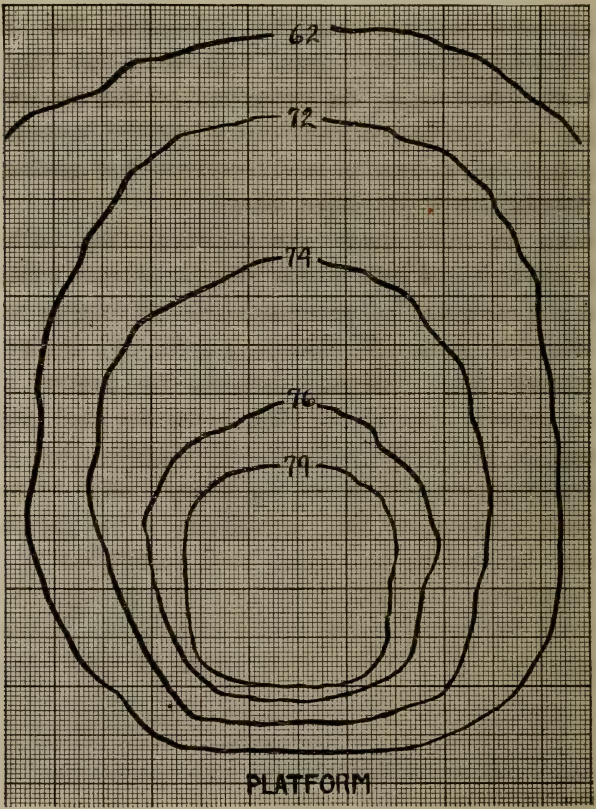

Fig. II—Topographic chart representing the approximate lines of performance of an audience early in the semester. Aisles or other obstructions would materially affect the "social gradients."

We are justified, it seems, in speaking of the topography of the audience where heights and depths are measured by degrees of social integration and hence amounts of individual achievement. If our tabulations represent the facts, a typical audience could be represented as in Figure II, where the lines represent levels of performance or degrees of achievement (expressed in numerical grades) and thus degrees of social integration. That is to say, a lecture audience is a polarized audience with reference to the speaker; but it is also integrated with respect to itself.

Our investigation has shown, in fine, that there is a well-marked variation in academic grades which is not due to a difference in mental ability or to other factors referable to the individual auditors. Neither is the variation due entirely to the distance of the auditors from the speaker. On the other hand, it does seem to be directly dependent upon position with reference to the total group. That is to say, when due allowance has been made for the factors mentioned above, and for the resulting mental organizations, a residual variation seems essentially to rest upon the varying degrees of social integration among the members of the group.

LEADING AND LEGIBILITY

By Madison Bentley

In the literate adult, reading is a rapid, smooth-running, and highly automatized performance, which may go on for a long time without noteworthy lapse or hesitation. It appears to be a simple operation, but it is not. Even in highly practiced subjects it can scarcely be called "simple," because it depends upon the coöperation of a large number of heterogeneous conditions. In the first place, the constant readjustment of the eyes to the page is complicated. The leaps and pauses which the eyes make in reading involve a complex and delicate mechanism. Again, the total state of the central organ and its functional tendencies, taken together with the mental concomitants of attention, associability, and the touching off of meaning, form a second set of conditions upon which reading depends. And, finally, the apprehension of the written or printed characters rests upon a large number of local factors which may retard or facilitate the process. In the reading of print, for example, the color and lighting of the page and of the print, the size and form of the type, the length of the line and the spacing of the letters, all have their effect upon the rapidity and the ease of reading.

These three sets of conditions, which we may roughly distinguish as peripheral, central and mental, and typographical, have suggested to psychology a great many problems. The conditions are all closely interrelated; but experimental progress has been made only when one factor or another has been isolated for study.[1] In our present small investigation, we have tried to isolate one of the "typographical" conditions;[2] the factor of

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[1] The psychology of reading has already acquired a large bibliography. Most of the older titles may be found in Huey, E. B., *The psychology and pedagogy of reading,* etc., New York, 1912. A number of recent pedagogical studies of reading are exemplified by the monograph, Gray, C. T., *Types of reading ability,* Chicago, 1917.

[2] A partial list of "typographical" conditions, naming twelve factors of this sort, is given by Legros, L. A., and Grant, J. C., in their large work on *Typographical printing surfaces,* etc., London, 1916, pp. 156-157.

"leading" or—more accurately—of the vertical distance between printed lines. The "leaded page" is a page in which the typesetter has inserted one or more thin metal strips (the thinnest, 1-point, lead is about 1/72 inch thick), called "leads," between the successive lines.[3] We do not here directly consider the typewritten page, where only two spaces between lines, single-space and double-space, are commonly used.

In Roethlein's study[4] of the relation between legibility and the characteristics of the type-face, it appeared that the rate and the ease of reading were affected—among other factors—by the amount and disposition of the blank space around each letter. This fact, taken together with the obvious difficulty of reading a crowded and close-set page, suggests that the open space between succeeding lines may be an important condition of legibility. The study, then, of this condition is our present problem.

Materials and procedure. The type-face used was of the style "monotype,"[5] a close approximation to "news gothic," a style which Roethlein found to stand relatively high in legibility. Figure I reproduces samples of our reading texts set in 12-point face and body, without leads (a) and with 7-point leading (b).

At first we used a large type (thicker and cleaner than the reproduction in Fig. I) in order that the sheets might be presented through a wide range of distances, and so offer to the reader varying degrees of difficulty. The type (12-point) was impressed on fine heavy paper, exactly ten full lines on each sheet. The line was 3 5/16 inches long, and the sheet was 6⅝

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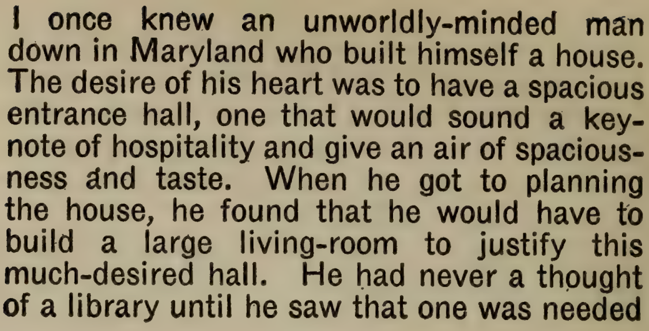
[3] The printers' unit of linear size is the "point" = 0.013837 in., approx. 1/72 in. Twelve points make the "pica," approx. 1/6 in. The interlinear space is not necessarily equivalent to the leading, since the type-face is sometimes smaller than the type-body. Thus a 10-point face upon a 13-point body would give the appearance upon the page of 3-point leading. We shall use "interlinear space" as the distance between the extreme projections (ascenders and descenders) of the small letters in succeeding lines. In our case, it will be the equivalent of the points of leading.

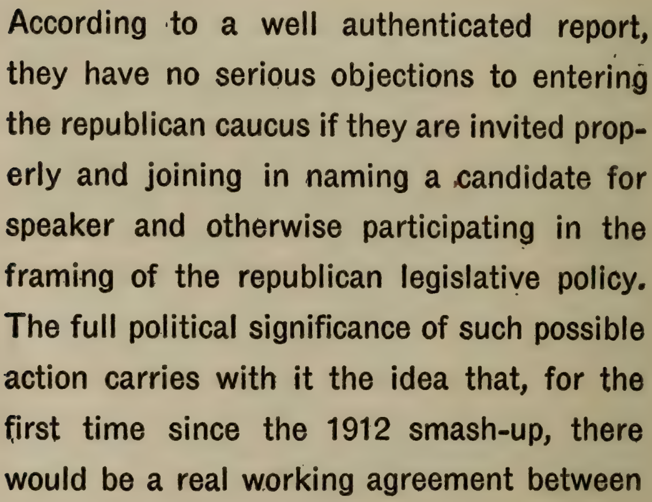
[4] Roethlein, B. E., The relative legibility of different faces of printing types, *Amer. J. of Psychol.*, 1912, xxiii, 1-36, esp. p. 28.

[5] The printing was done with great care and pains by Messrs. R. R. Donnelley & Sons Company, Chicago, to whom the Laboratory stands under a heavy debt. It was arranged for and followed through the press by Dr. Carl Rahn.



I once knew an unworldly-minded man down in Maryland who built himself a house. The desire of his heart was to have a spacious entrance hall, one that would sound a keynote of hospitality and give an air of spaciousness and taste. When he got to planning the house, he found that he would have to build a large living-room to justify this much-desired hall. He had never a thought of a library until he saw that one was needed

FIG. Ia



According to a well authenticated report, they have no serious objections to entering the republican caucus if they are invited properly and joining in naming a candidate for speaker and otherwise participating in the framing of the republican legislative policy. The full political significance of such possible action carries with it the idea that, for the first time since the 1912 smash-up, there would be a real working agreement between

FIG. Ib

x 7½ inches. The sheets were set upon an exposure-frame which was movable along an optical bench in the dark-room. The whole was surrounded by a rectangular wire frame covered the black cloth, making a long rectangular tunnel, 9 in x 12 in. The subject was adjusted to a head-rest and looked into the black tunnel down which he could see the printed sheet. The printing was evenly illuminated by concealed electric lamps and by reflectors. After a warning signal, the field was suddenly exposed by the experimenter, and the subject read aloud the ten lines at top speed. An indicator showed the subject in advance just where the first line would begain, and he recorded his beginning and ending times by means of a finger key and an electrically controlled stop-watch.

In order to ascertain the visual angle ordinarily subtended by the length of the line as printed in books, magazines, and newspapers, and also to procure variety in the substance of the excerpts to be read by our subjects, we took extracts from eight books, written upon a variety of topics, eight magazines, serious and popular, and eight newspapers, representative of this country and England. We gathered in this way materials for 90 extracts, each 10 lines long. Thus we had 9 excerpts for each of 10 leadings (0 and 1, 2, 3 . . . . 9-point), and the whole 90 were exposed in a mixed order to each of our readers. We took care that the order observed should equally distribute the variable error of practice to all the 10 degrees of leadings used at a given reading-distance. The effects of practice which may have been cumulative as the experiments passed from one reading-distance to another are not wholly eliminated because we did not at first anticipate the exceedingly wide range of distances which we were to use. These effects were practically cancelled by carrying 2-4 distances on together. They have no special significance for our problems. Fatigue was avoided by short periods of reading and frequent intervals of rest. We kept, so far as we could, to the same hour in the day for a given subject; although our whole series of experiments, running through four years, covered nearly the entire day from 8 a. m. to 5 p. m.

Before the reading began for the hour, the following instructions were read to the subject:

> "At a signal 'ready' you will be shown a grey exposure field. Fixate the white pointer. At a second signal, 'now,' the grey field will be removed, disclosing a block of printed matter. Begin immediately to read aloud and at the same time press the key at your right hand. Read as clearly and as rapidly as you can. Do not correct errors. If a strange or an unclear word appears, say 'blank' and continue reading. As you read the last word press the key a second time. After the reading, report the number of mistakes made."

We at first proposed to include an introspective study of the processes involved in reading and especially those affecting the rate; but we later discovered that such a study properly belonged to a separate inquiry.[6]

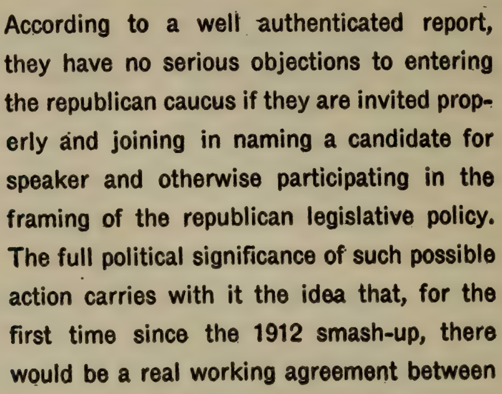


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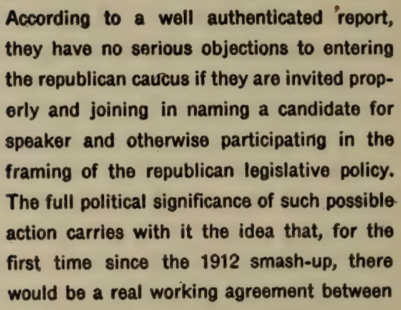
Fig. IIa



According to a well authenticated report, they have no serious objections to entering the republican caucus if they are invited properly and joining in naming a candidate for speaker and otherwise participating in the framing of the republican legislative policy. The full political significance of such possible action carries with it the idea that, for the first time since the 1912 smash-up, there would be a real working agreement between

Fig. IIb

We drew our readers, 18 in all, from the departmental staff, from graduate students of psychology and from advanced undergraduates, most of whom were pursuing experimental problems.[7] It was soon found that the subjects best adapted to the problem were those who maintained a steady and constant reading "set" which kept them under pressure to do their best and to complete the reading in the shortest possible time. In a comparative study of reading-times much depends upon the steadiness of this psychophysical determination. All the readers save R read without knowledge of the problem. The substance of the excerpts had, of course, its influence upon the rate of reading; but our wide choice (90 extracts from a wide variety of topics, ranging from epistemology to light fiction and the fashions) was designed to distribute to the various leadings the influence of the meaning-substance upon rate. The results seem to justify our assumption.[8] The whole number of readings was 6640. As the experiment progressed, it seemed advisable to secure a wider range of the size of type and also of reading distances. To this end, we procured from the University's photographer photographic reductions of our sheets set in 12-point type. These reductions were made on the scales of 1.0 to 0.72 and 1.0 to 0.60, and they represent approximately 9-point and 6-point types. In the reductions, the thickness of the single lead (1/72 inch) became approximately 1/100 inch and 1/120 inch.[9] We might have kept to our large type and regarded only retinal size, but we did not care to assume that a large type at a great distance would be read with the same facility as a small type at a smaller distance, *provided only* the visual angles subtended by the two types (and, of course, the two line-lengths) were the same. The conditions of reading are too complex to warrant such an assumption. Habitual reading, *e.g.*, at a given distance (as the "normal reading-distance" for the emmotropic eye) might favor that distance from the eyes. So we used the three sizes of text at many distances. In general, the 6-point and the 9-point were

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[6] In the first four thousand and more readings, the experimenter carefully followed the reading, with a duplicate copy of the excerpt before him, and set down on a prepared blank the errors committed. The errors consisted of hesitations, blanks, wrong words, new insertions, attempts at corrections, breaks in the voice, nervous laughter and ejaculations. We had hoped to relate these lapses, as well as the mental processes which underlay them, to the time of reading the ten lines; but that also proved to be impracticable because of the variable factors of sense, meaning, and degree of familiarity. The introspective study still lies before us to be completed.

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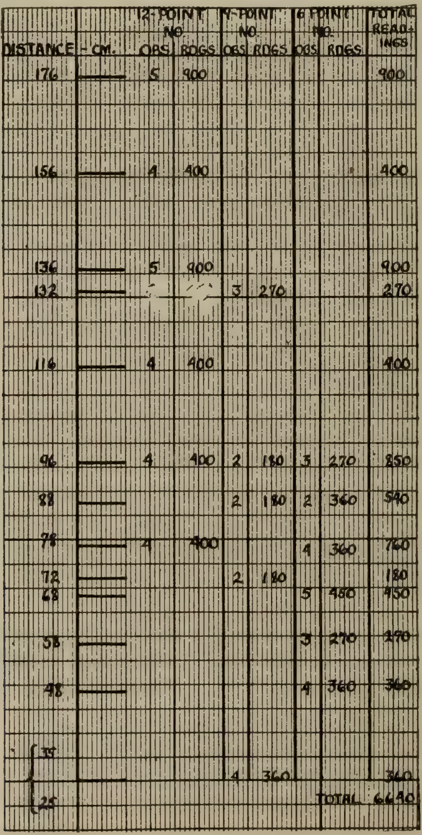
[7] The experiments are the work of many hands. A large part of the earlier work of planning, devising, and overseeing fell to Dr. Carl Rahn, who also served as observer. One whole division fell under the guidance of Professor C. A. Ruckmick. The experiments were placed in the competent hands of Mr. W. T. Doe, B.A., and Mr. L. C. Raines, B.A. Some of the later series were carried through by Miss M. Jones. The readers who were good enough to give their time and their enthusiastic effort were Broom (Br), Bentley, Dr. R. C. (B), Cuthbert (C), Carman (Ca), Carlsen (Cl), Fluke (F), Fera (Fe), Griffith (G), Goebel (Gb), Gould (Go), Greene (Gn), Gross (Gr), Knapheide (Kn), Kohl (K), McKinney (Mc), Rahn (R), Raines (Ra), and Rutherford (Ru). The graphs have been drawn by Dr. C. A. Griffith.

[8] The Laboratory is to carry through another study which makes use of nonsense syllables and nonsense words. That sort of reading will, of course, be very different (in character and mechanism) from the perusal of the ordinary sense page.

[9] An independent variation of type-size and leading would have been preferable to our photographic reductions, but the expense of the typesetting was formidable. We shall speak of 0-lead, of 7-leads, etc. in the photographic reductions, for the sake of simplicity; although the actual interlinear distances have been changed.



		12-POINT		9-POINT		6 POINT		TOTAL READINGS
DISTANCE	- CM.	NO. OBS	RDGS	NO. OBS	RDGS	NO. OBS	RDGS	
176		5	900					900
156		4	400					400
136		5	900					900
132				3	270			270
116		4	400					400
96		4	400	2	180	3	270	850
88				2	180	2	360	540
78		4	400			4	360	760
72				2	180			180
68						5	450	450
58						3	270	270
48						4	360	360
35 25				4	360			360
							TOTAL	6640

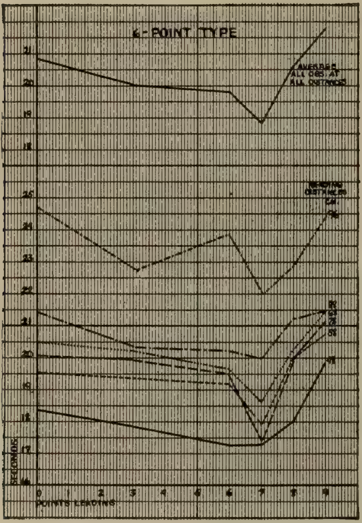
FIG. III

read at the smaller distances. Figure II shows samples (7-point leading) of these two blocks of type, while Figure III displays the distances at which each type (at the various leadings) was read.

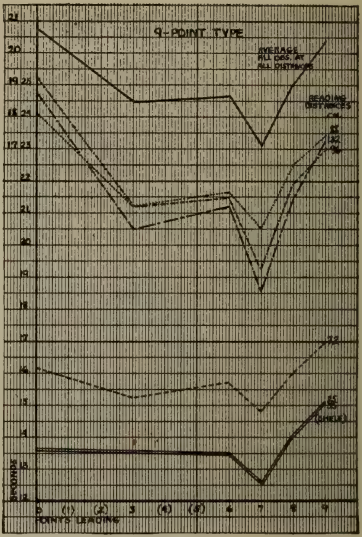
The readings taken at a distance of 25-35 cm. call for a special description. It seemed advisable to compare our results acquired in the dark room under somewhat unusual conditions with printing which should be presented to the subject as he ordinarily reads. To this end we arranged a reading desk at an optimal inclination and with good indirect light derived from a large window obliquely behind the subject. We used the same care as elsewhere in the exposure. The reader made his own finer adjustment to distance by moving his head backward and forward while a preliminary card rested upon the reading desk. The distance chosen was read off (cornea to plane of printed sheet) just before beginning and just after finishing a set of excerpts. With our 9-point types, all the distances fall within the limits of 25-35 cm. (ca. 10—14 in.) The range was fairly narrow for any single reader.

Results: The general trend of the reading-times at the various distances and with the ten leadings, 0-9, is shown upon our graphs. Here the number of leads (separation of the lines) is set down at the bottom of the sheet and the time (sec.) expended on reading the ten lines of printed matter is set upon the line of ordinates. After a careful inspection of results we decided to include in the graphs only leads 0, 3, 6, 7, 8, 9. The others appeared to have no special significance. All the times for any one size of type (6-, 9-, or 12-point) are gathered together in one place, each graph standing for all readings at a given distance. Above each group is a compound graph which combines all those beneath it, *i.e.,* all 12-pt., or 9-pt., or 6-pt. results. The unbroken lines in each group represent one and the same set of observers, the broken lines another set, and so on. The times of the individual subjects (ave. of each reader's trials at a given distance) are given in figures in Table I.

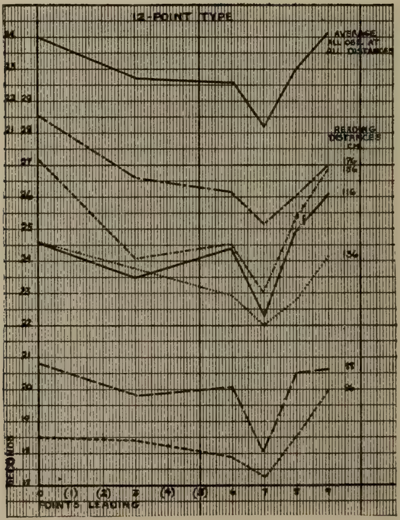
As regards the reading-times for different distances and for different type-sizes, the inspection of the graphs will make it apparent that, in general, the greater the distance of the page from the eye the longer the reading-time. This rule obtains where the group of observers is the same for different graphs and also,—usually, not always,—where different observers read at



Graph I



Graph II



Graph III

TABLE I

12-Point Type

Subj.	0	3	6	7	8	9	Lowest
Distance = 176 cm.							
B	23.4	22.9	22.5	20.8	21.3	22.8	7
C	26.8	26.5	26.4	25.2	26.6	28.3	7
F	30.6	30.2	29.3	29.1	28.9	30.7	5(28.5)
G	18.0	17.0	16.1	16.0	17.1	17.3	4(15.9)
R	43.1	36.6	36.9	34.8	36.1	35.9	7
Ave.	28.4	26.6	26.2	25.2	26.0	27.0	
Distance = 156 cm.							
Ca	26.6	25.1	25.6	23.7	25.5	29.5	7
Gr	31.1	25.0	27.3	25.6	28.4	30.1	3
Mc	31.5	28.5	27.6	26.1	30.0	29.9	7
Ra	19.7	17.8	17.6	16.5	17.4	18.2	7
Ave.	27.2	24.1	24.5	23.0	25.3	26.9	
Distance = 88 cm.							
Ca	24.7	24.2	24.2	21.8	24.9	24.5	7
Gr	18.7	17.3	18.7	17.2	18.5	18.5	7
Mc	23.6	22.4	21.7	19.3	22.4	23.3	7
Ra	15.9	15.3	16.0	14.1	16.3	16.1	7
Ave.	20.7	19.8	20.1	18.1	20.5	20.6	

Subj.	0	3	6	7	8	9	Lowest
Distance = 136 cm.							
B	19.4	19.2	18.2	17.9	18.2	19.5	7
C	29.8	28.2	28.5	26.7	27.9	30.1	7
F	23.0	23.2	23.5	22.3	23.1	25.0	7
G	17.4	16.4	16.3	16.6	16.7	17.8	4(15.9)
R	33.2	31.1	27.4	26.7	25.4	28.5	8(25.4)
Ave.	24.6	23.6	22.8	22.0	22.7	24.2	
Distance = 116 cm.							
Ca	21.1	22.3	23.1	21.3	24.2	26.9	1(21.1)
Gr	25.6	23.2	24.8	22.3	24.5	25.2	7
Mc	26.6	23.7	24.0	22.8	24.4	26.2	7
Ra	25.2	24.9	25.6	22.6	26.5	26.2	7
Ave.	24.6	23.5	24.4	22.2	24.9	26.1	
Distance = 96 cm.							
Cl	22.8	22.1	21.5	20.1	20.7	22.8	7
Go	18.2	18.7	17.2	18.3	18.9	20.5	6
K	17.5	17.1	17.3	15.6	17.5	18.7	7
Ra	15.4	15.6	15.1	15.1	17.1	17.6	6 & 7
Ave.	18.5	18.4	17.8	17.3	18.5	19.9	

9-Point Type

Subj.	0	3	6	7	8	9	Lowest
Distance = 132 cm.							
Fe	22.8	19.1	18.8	16.0	17.5	21.3	7
Gn	28.4	21.2	24.0	20.6	25.2	26.4	7
Ru	24.0	21.4	20.9	19.3	21.4	22.0	7
Ave.	24.7	20.6	21.2	18.6	21.4	23.2	
Distance = 96 cm.							
Cl	30.0	23.4	23.8	20.6	24.0	24.4	7
Gn	20.4	19.0	19.2	18.0	19.6	21.8	7
Ave.	25.2	21.2	21.5	19.3	21.8	23.1	
Distance = 25-35 cm.							
Br	11.9	12.1	11.9	10.7	11.9	13.0	7
Cl	11.8	11.4	11.4	11.0	11.7	14.0	7
Kn	15.8	15.6	15.4	14.6	16.2	17.1	7
Ru	15.3	15.5	15.5	14.6	16.2	16.9	7
Ave.	13.7	13.6	13.5	12.7	14.0	15.2	

Subj.	0	3	6	7	8	9	Lowest
Distance = 72 cm.							
Fe	14.4	13.6	13.8	12.7	14.1	15.2	7
Ru	18.0	17.0	17.7	16.9	17.9	18.8	7
Ave.	16.2	15.3	15.7	14.8	16.0	17.0	
Distance = 88 cm.							
Cl	26.7	22.4	22.1	21.6	24.3	25.0	2(20.3)
Gn	21.5	20.0	21.2	19.4	20.5	21.8	7
Ave.	24.1	21.2	21.6	20.5	22.4	23.4	

TABLE I (Continued)

6-Point Type

Subj.	0	3	6	7	8	9	Lowest	Subj.	0	3	6	7	8	9	Lowest
	Distance = 96 cm.								*Distance = 58 cm.*						
Gr.	27.1	24.7	25.3	23.4	24.4	26.4	5(22.4)	Gr	19.0	17.6	17.2	17.2	17.8	19.0	5(16.7)
Mc	30.7	27.8	29.8	27.4	27.5	29.5	7	Mc	24.0	24.1	24.0	21.2	24.4	25.3	7
Ra	16.4	15.9	16.4	15.6	16.5	17.2	7	Ra	15.9	16.5	16.4	15.2	17.8	18.2	7
Ave.	24.7	22.8	23.8	22.1	22.8	24.4		Ave.	19.6	19.4	19.2	17.9	20.0	20.8	
	Distance = 68 cm.								*Distance = 48 cm.*						
Cl	28.8	25.5	23.9	22.7	25.1	24.8	7	Cl	22.3	20.7	20.1	20.5	20.5	23.2	4(18.8)
Gb	18.6	17.1	17.6	15.3	17.0	19.0	7	Gb							
Go	21.1	20.1	20.3	19.2	21.5	22.5	7	Go	17.2	17.5	17.6	17.3	18.3	19.5	0&2(17.2)
K	17.0	20.7	19.6	19.5	20.4	21.3	1(17.1)	K	17.3	16.3	15.8	15.8	15.8	18.2	1, 2, 6, 7&8
Ra	16.8	18.1	16.6	16.2	17.6	19.4	7	Ra	16.6	16.8	15.9	15.7	17.3	17.8	7
Ave.	20.5	20.3	19.6	18.6	20.3	21.4		Ave.	18.3	17.8	17.3	17.3	18.0	19.7	
	Distance = 88 cm.								*Distance = 78 cm.*						
C	27.0	25.9	26.3	26.0	27.4	26.7	2 & 5	Ca	21.1	19.4	20.2	18.0	21.0	21.6	7
G	15.8	15.0	14.3	14.1	15.2	16.2	7	Gr	17.5	20.6	19.9	15.9	18.1	20.0	7
								Mc	26.1	24.2	22.6	21.0	24.2	25.4	7
								Ra	15.6	15.4	15.5	14.8	17.0	17.3	7
Ave.	21.4	20.4	20.3	20.0	21.3	21.4		Ave.	20.1	19.9	19.5	17.4	20.1	21.1	

different distances. Reading of 9-point type at the common distance of 25-35 cm. (in daylight), 12-point type at our shortest distances, 88 cm. and 96 cm., and 6-point type at 48 cm. give the shortest general times.

The most obvious regularity in the numerical result appears upon a comparison of the three "Average" graphs at the top. In absolute time they differ somewhat, the curve for 12-pt. running highest (beginning at 24 sec. and ending at 24.1 sec.); but in form they are virtually coïncident. There is a steady decline in reading time from the type "set solid" (0-leading) to 3-point leads, little or no decline to 6-point, then a dip to 7 and a rise to 9. The two end-times, 0-lead and 9-point, are about the same. With all three type-sizes and at all distances the minimal time uniformly appears with 7-point lead, a result which is reproduced in most of the average times of all the individual subjects (see "Lowest" column in Table I).[10]

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[10] This uniformity in the results appears especially noteworthy when we consider (1) that the range of average times for a Subj. throughout the

The amount of time actually saved in reading by the increase of the interlinear space from 0 to 7-point leads varies with the size of type and with the reading distance. Thus the optimal leading saves at the rate of about 8.5 minutes in the hour with 12-point read at 156 cm., and about 5 minutes in the hour at 88 cm. With 6-point, the saving is as much as 8 minutes (78 cm.) and as little as 3 minutes (48 cm.). The 9-point texts, which approximate much of the common type of our books and periodicals, showed a saving of the optimal over the minimal leading of about 15 minutes in the hour at a reading-distance of 132 cm.. At the usual reading distance (about 12 inches), however, the saved time fell to about 1/13, or a little more than 4 minutes in the hour. All of these reductions in time, it should be noted, are obtained with an exceedingly clean and legible type. The saving might be still greater with a bad type-face which should offer internal difficulties within the line.

The dip in the curves at 7-point leading is curiously constant and strikingly regular. It appears in the several graphs representing the several distances (25-176 cm.) and with all groups of observers. If the ends of the graphs are covered, exposing only the sections 6 to 8, it will appear that the dip or "V" is nearly symmetrical,—that the drop from 6 to 7 and the rise from 7 to 8 have practically the same inclination, *i.e.*, leadings 6 and 8 are read with approximately the same facility, while leading 7 is distinctly shorter in time. At this point—7 leads—the vertical distance between lines is, for 12-point type, 1/72 x 7 = ca. 1/10 in. For the (reduced) 9-point type, it is 1/100 x 7 = ca. 1/14

different leadings did not often exceed 5 sec., and (2) that the m.v. of the reading-times for any singe leading turned out to be relatively large by reason of the variety of topics treated in the ninety excerpts. The following is a typical instance.

	Leads	0	1	2	3	4	5	6	7	8	9
Subj. C at 136 cm.	Times (in sec)	29.8	29.4	29.4	28.2	27.8	27.2	28.5	26.7	27.9	30.1
	m. v.	3.9	2.0	3.2	1.3	3.1	2.8	3.2	3.2	2.3	1.6

The wide variation in reading-times arising from the greater or lesser difficulty offered by the text led us to depend less upon the m. v. as a measure of reliability than upon an accumulation of readings sufficiently extensive to eliminate the variable error due to the assimilation of meaning.

in.; and for the (reduced) 6-point, 1/120 x 7 = ca. 1/17 in. The dip, then, at a 7-point lead appears (a) at any given reading distance and with three different interlinear gaps: it also appears (b) throughout a wide range of visual angles. It seems, then, that the critical or optimal leading is not entirely a matter of the interlinear spacing, of the clear space left above and below the line, and not entirely a matter of the drop of the eye in passing from the end of one line to the beginning of the next. It appears rather to depend upon the *ratio*[11] of letter-height (H) to interlinear space (S); *i.e.,* upon the ratio H/S.

Now what the factors are which make our particular ratio for 7 leads (H/S = 1.7)[12] optimal for reading under our conditions, we can only conjecture. The determination of them belongs to another study. It is probable that the eye-movement is not alone concerned,[13] for our three line-lengths, $3\,^{5}/_{16}$, $2\,^{8}/_{16}$, and 2 inches, yield the same results; and if it were merely a matter of clear space about the centres of fixation upon the line, there is no reason why lines separated by 8-point and 9-point leads should be more slowly read than 7-leaded lines or why small type (as 6-point) should require only a small clear interlinear space while larger type requires a larger clear setting.

It is altogether likely that the conditions underlying this dependence of facility of reading upon leading are complex. We began with the observation that reading is a complicated operation. It appears now that a slight variation of a factor so simple as the interlinear space may involve complicated ocular movements throughout and between the lines, indirect vision, attention under distractors, and little known central conditions which are responsible for the emergence of meaning from the apprehension of the symbolic characters of the printed page. The methodical and technical means are at hand for the analysis of such a tangled set of conditions; but the application of them will require further experimentation.

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[11] It should be noted that our line-length is always a function of this ratio. The line-length follows letter-height wherever the visual angle changes, whether from shift of reading-distance or from photographic reduction of the text. The dependence of reading-rate upon the length of line we are pursuing further.

[12] The vertical height of the 12-point letter (including ascenders and descenders) is approximately 1/6 in. Seven-point lead, at 1/72 in. for each point = 7/72 in., and 1/6 ÷ 7/72 = 1.7.

[13] For a bibliography of the study of eye-movements see Schmidt, W. A., *An experimental study in the psychology of reading,* Chicago (Univ. of Chicago Press), 1917.

Summary. It appears upon the evidence of the experiments that facility and rate of reading the printed page are dependent, among other factors, upon the vertical space left between the lines (leading). Under our conditions, unleaded, or closely set, matter was read with relative slowness. With increase of the interlinear space, the rate of reading increased up to 1/10 inch (7-point leading), and then rapidly declined.

THE PRINTING OF BACKBONE TITLES ON THIN BOOKS AND MAGAZINES

By P. N. Gould, L. C. Raines, and C. A. Ruckmick

To those who have been working in libraries containing magazines in their original covers and bound books of few pages it has probably become noticeable that a very unfortunate lack of uniformity exists in the printing of titles lengthwise on the backs of these magazines and books. While there is in different countries a general disposition to conform to some standard of printing, there is by no means an agreement on the subject in any one country. In general and with many exceptions, the European plan is to print such titles from bottom to top, while the American plan, if there is one, is to print in the reverse direction. A considerable amount of discussion has arisen on the subject, especially in connection with library practice and in the printers' journals.[1] There are related questions, such as the subscriptions to full-page plates inserted in reading material,[2] and the insertion of omitted matter in writing when the insertion is titled in one direction or the other.

Many persons, in discussing the subject, seem to take the view that while they may have individual preferences in the matter they would be willing to set these aside if a universal practice could be established. Libraries insist, for the most part, on the advantages derived from printing titles in the direction from top to bottom, arguing that when magazines are stacked on tables, newsstands, and temporarily on shelves, the logical direction, with the face up, would be from top to bottom, or, when they are in this position, from left to right.

Some preliminary investigations, though crude, have been made on the question, but so far apparently no experimental work has been published. One preliminary study resulted in the decision of seven in favor of printing from bottom up and two in placing the lettering from top down. Three additional answers, however, were noncommittal. In another inquiry an investigator found that among men of his own staff who were preserving pamphlets and frequently writing titles themselves on the backbone, nine out of ten were using the method which involved printing from bottom to top. Three out of four of them declared that any other method was unnatural. On the other hand, so eminent an authority as Melvil Dewey says, "The statement that it has been demonstrated by tests to be easier and more natural to read from bottom to top contradicts all the experiments and investigations I have made for forty years."

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[1] *American Printer,* August 5, 1918. *Printing Art,* 1918, xxxii, 62. *Publishers' Weekly,* 1918, xciv, 1763, 1994.

[2] *Preliminary Report of the Joint Committee on Standards for Graphic Presentation,* Amer. Soc. of Mech. Eng., N. Y.

Obviously, on further consideration, there are a number of circumstances which are indirectly involved in the question. If ease of reading is to be a criterion, then the way in which the head is more readily inclined undoubtedly has an important bearing. A great number of individuals, from replies received on the subject, indicate that it is easier for them to tilt the head to the left. And, indeed, there is some basis on the side of the musculature of the eyes, neck and shoulders which might favor this inclination.[3] It is possible, also, that the tilt of the head in writing, being for the most part to the left, has a bearing on the problem. One correspondent, for instance, noted that during the time that he was learning to read and write Hebrew and for some time thereafter his head would habitually tilt to the right instead of to the left. Another authority widely known for his investigations of eye-movement states that he has noticed the invariable practice of right-handed people tilting their penmanship upward, while left-handed individuals habitually write downward.

A relatively large number of individuals have remarked that a differentiation exists between the use of either hand in taking books from the library shelves, the left hand being used to withdraw the book from the shelf while the right is preparing to finger the pages, and in this position the body would be more inclined toward the left. All of these suppositions are conditioned by the height of the shelf above or below the level of the eyes, as well as by the location of the shelf to the right or to the left of the individual. Several replies indicate also that the lighting effect may be a complicating factor. Those who argue in favor of printing from top to bottom seem to be impressed by the analogy of reading printed lines from the top of the page down to the bottom. But it is not unlikely that the analogy is overdrawn and that the factors involved in reading titles of books, when printed at right angles to the usual movement of the eyes, presents a totally different situation from the ocular excursions of ordinary reading.

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[3] See the discussion of head-movements relative to Listing's Law in Helmholtz, H., *Handbuch der physiologischen Optik*, 3rd ed., vol. iii, Hamburg and Leipzig, 1910, pp. 120-123.

EXPERIMENTAL SERIES

Apparatus. The entire problem was taken over as an experimental investigation in the psychology laboratory, and conditions were devised to simulate those of the library. In one of the dark rooms of the laboratory a shelf was designed to be fastened in a number of positions on the wall, being adjusted to heights of four, five and six feet from the floor, these being standard heights in library practice. On the shelf about a score of books were placed and among them a so-called "dummy" was inserted. This dummy measured 26 cm. long by 2 cm. thick. Along its front edge a sliding arrangement was provided into which printed titles could be placed. These titles were printed on heavy white paper and consisted of thirty-eight different names of standard American publications such as:

THE GEOGRAPHICAL WORLD
THE AMERICAN FORESTRY
THE AMERICAN WOOL REVIEW
DUNN'S INTERNATIONAL REVIEW
THE MARINE REVIEW
THE CONTEMPORARY REVIEW

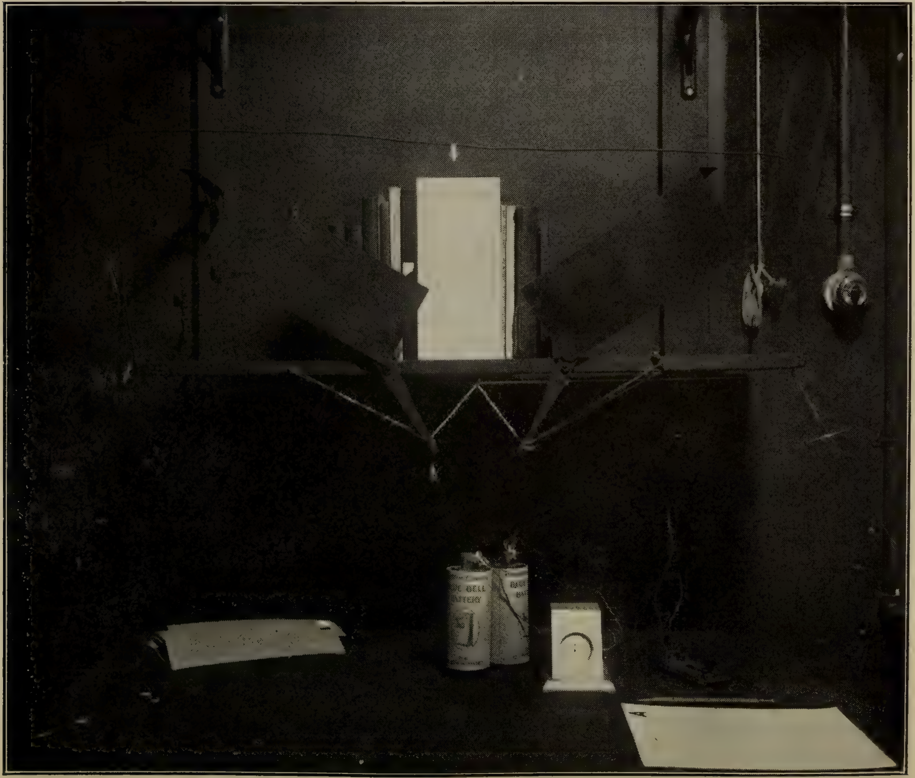

FIG. I

In front of the shelf a double scissors-like shutter was provided which would expose to view the entire length of the "dummy" and some of the neighboring books without suggesting by its own movement the direction to be followed in reading. Later in the experimental series, the "dummy" was replaced by a device that would hold six or more titles at once, the shutter was opened through an arrangement of strings, elastic bands, and pulleys, operated by the experimenter. An electrically operated stopwatch was used to time exposures and reactions of observers. The entire shelf and shutters were painted a dead black and the room was lighted uniformly by means of an artificial "noon-day" light of high power. In another part of the experiment a head rest was provided. The observer was uniformly three feet in front of the title to be read. A pointer was affixed to a wire-frame to indicate the approximate place at which the titles were to be read.

Procedure: The experimental investigation began early in 1919 and lasted through the summer of that year. The observers, fourteen in number, were selected from among the advanced classes in experimental psychology. They were given instructions to read aloud as clearly as possible, and at their normal speed, the title that was to be presented to them. Introspections were recorded in about half the cases.

The series were divided, in the first group of experiments, so that 36 observations were taken with the titles at the level of the eyes, the same number below, and an equal number above the level of the eyes. It was soon found that the reading of a single title could not be accurately timed under the conditions of the experiment, so, for the most part, cards were made up of from four to eight titles running in the same direction, to be read consecutively, and the resulting time divided by the number of titles read. In the second group of experiments the observers were asked to walk from a spot about five feet to the right or to the left of the shelf and then walk towards the shelf, on the assumption that entrance to the room constantly from one direction would itself influence the observer *to favor* one side or the other.

In a final group the observer's head was placed in a head-rest which prevented movement to either side.

In each case, after the observer had taken his position the experimenter would open the shutter and release the stop watch with the same movement. When the reading was completed the watch was electrically stopped. The arrangement of the cards was determined by a chance order but care was taken that each presentation to the left, that is from bottom to top, was at some place matched by a presentation of the same material in the opposite direction.

As a result of our questionnaire (see below) we have also the unpublished records of some class experiments conducted by Professor A. P. Weiss of the Ohio State University and of a few individual experiments performed in the same laboratory. Some disjointed printed material mounted on a board and 200 words in length was presented to the observer to read aloud as rapidly as he could accurately do so. The time was recorded in seconds. Both the copy and the observer were given a variety of positions, *viz.,* (1) the copy upright and the observer upright, material read from left to right; (2) copy upside down, observer erect, material read from left to right; (3) copy turned to the left 90 degrees, observer erect, material read from bottom up; (4) copy turned to the right 90 degrees, observer erect, material read from top down; (5) copy turned to the left 90 degrees, observer bending to the left 90 degrees, material read from bottom to top; (6) copy turned to the left 90 degrees, observer bending to the right 90 degrees, material read from bottom to top; (7) copy turned to the right 90 degrees, observer bending to the left 90 degrees, material read from top to bottom; (8) copy turned to the right 90 degrees, observer to the right 90 degrees, material read from top to bottom.

The time values in these series do not present significant differences. For example, there is a difference of only two seconds in the median values of series 5 and 8, which series approximate most closely the question raised in our problem. It is significant, however, that out of fourteen observers who expressed a preference for one of the last four positions, eleven preferred position 5, two preferred position 8, and one was doubtful regarding 5 or 8. This apparently gives a favorable vote to the position which involves bending to the left and reading material from bottom to top.

Observations were also taken by five persons, in the library, to ascertain which way the head and body are bent when reading book titles in the stacks. In 187 cases observed, 29 per cent. bent voluntarily to the right, while 71 per cent. bent voluntarily to the left. Obviously these results should be suitably qualified by reason of the fact that they were not obtained under experimental conditions. Such factors as differences in illumination, position of books as regards the aisles, just previous position of the observer, height of books from floor and similar circumstances, clues to which could very likely be obtained in individual reports, were not taken into account. The figures speak for themselves only in the mass. And yet, of course, when so taken they are very good indicators of a possible conclusion.

Results: As far as our own statistical records go, the time values and also the number of times which indicated a faster reading for one or the other direction show no general significant features. The reading times indicate the least variation when comparisons are made in the values obtained in reading upwards with those obtained in reading downward. There is, of course, large individual variation with the observers. The only figures that seem to have any relevancy are the total times that the series was read faster in one direction than in the other, and there, only as regards that phase of the problem which took into account the height of the shelf from the floor and the direction from which the shelf was approached. When the shelf is above the level of the eyes the bottom to top direction is most favorable, whether it is approached from the right or the left, although slightly more so when approached from the right. In 69 per cent. of the cases the times were faster from bottom to top and in 31 per cent. they were faster in the reverse direction. When these percentages are factored into values which signify the direction from which the shelf was approached, we find that the value for the approach from the observer's right reaches as high as 77 per cent., whereas that for the approach from the observer's left decreases to 59 per cent. At the level of the eyes there seems to be no appreciable difference in time values or in the number of times either direction is read faster. This is markedly true in the series in which the head was fixed. In the series in which the shelf was placed below the level of the eyes, there is a slight preference for the top-to-bottom direction as expressed in the number of times this direction was read faster. The percentages are: .57 for the top-to-bottom and .43 for the reverse direction. When these values are factored into figures which indicate the direction of approach, they increase so that the top-to-bottom direction is .64 when approached from the right and .49 when approached from the left. The writers, however, wish to emphasize the fact that there is so slight and sometimes so inconsistent a difference in the actual time values for reading in one or the other direction, that comparatively little evidence in favor of printing titles uniformly either from bottom to top or from top to bottom is forthcoming from the mere statistical account of our investigations and more stress is to be placed on the observers' comments. Stated in other words, as a matter of sheer efficiency gauged in the time actually spent reading the titles, we find no noteworthy or uniform difference.

Something must be said, nevertheless, both for the mental attitude of the reader as regards his reaction to the confusion which now obtains respecting the printers' and publishers' practice and for the time that may actually be lost before the reading of the title is begun. This latter value was, of course, omitted entirely from our calculations. It is a value hard to obtain, and compares with the well-known "fore-period" of the reaction-time experiments.

The introspective comments in almost every case diclose prominent kinaesthetic sensations localized about the head and neck and occasionally in some of the larger trunk muscles. These appear before the reading is begun and last through the reading period. Frequently they are affectively colored, and unpleasantly so before a sudden change of position, *e.g.*, when the direction of reading is opposite to that anticipated. To quote:

> "Slight tendency to tilt head according to reading of card. Tendency to read from bottom to top of card. Cards blurred more or less by fixed position—eyes used to slight tilting of head to ease strain of reading."
>
> "Pleasantly colored sensations while waiting for opening of shutter—desire to begin quickly. Unpleasant emotion when top of sheet is at the right, pleasant when at left (bottom to top)."
>
> "When the cards were perceived to read bottom to top, there was a kinaesthetic sensation in the neck resulting from turning the head to the left side."
>
> "When cards were shown there was an involuntary kinaesthetic twitch in the muscles of the eyes toward the upper right-hand corner in all cases."
>
> "When the cards were exposed there was a kinaesthetic sen-

sation of movement of my eyes to the lower left-hand corner of the cards. If I perceived that this was the point at which it was easiest to begin reading (if the lines ran upward) I began reading at once without difficulty. In case they ran downward, however, it was necessary to focus my eyes at the upper right-hand corner."

It is clearly seen that the mental accompaniments of the reading must be taken into account. They parallel the actual reading in many cases without disturbing the reading time. In most cases, however, there are kinaesthetic adjustments made in anticipation of the reading and if these are later to be altered an unpleasant affection results which seldom disturbs the reading. It is barely possible that if the experiments were to be continued and the time accurately measured from the opening of the shutter to the beginning of the reading, especially if the reading were done through an electrically controlled lip-key or the Dunlap voice-key, significant time values would result for the two directions.

QUESTIONARY SERIES

While the investigation was proceeding, some 92 answers to questionnaires were received, about one-half of this number from colleagues on the faculty of the University, and the other half from psychologists selected from the American Psychological Association. A copy of this questionnaire follows.

Dear Sir:

Librarians and others are just now discussing the problem of printing titles lengthwise on the backs of periodicals and thin books. Some maintain that the more readable direction is from top to bottom; others take the opposite view. The question has been referred to us for experimentation and the investigation is now under way.

In connection with the experimental results that we are obtaining, it is of interest to us to learn the personal opinions of those who are accustomed to the use of such material. For this reason we should very much like an expression of your reaction to the following statements:

(1) When publications of this sort are in position on a book-shelf among other miscellaneous books, I find that I am inclined to read the title more readily when printed from { top to bottom
{ bottom to top

(2) There are circumstances, however, which may modify this inclination; these are:

(3) When inscribing titles along the backbone of reprints inserted in covers, I usually write them from
{ top to bottom
{ bottom to top

(4) I am normally
{ right-handed
{ left-handed

A number of affiliated questions are frequently raised in this connection. Among them are: (a) Is the head generally inclined more readily to one side than the other or are there frequent variations? (b) Does the predisposition to read lines from left to right and from top to bottom affect the question raised? If you care to discuss these questions or related questions on the back of this sheet in addition to your answers to previous questions, we should be glad to hear from you.

Thanking you for your coöperation, I am

Very truly yours,
(Signed) Christian A. Ruckmick.

When the votes are counted without reservations we find 48 in favor of reading from bottom to top and 34 in favor of the reverse direction. Fifty-three were in favor of writing the titles on the backbones of monographs from bottom to top, and 30 in the reverse direction. In this connection it is interesting to note that while some indicate a preference in reading from top to bottom they state in reply to the third question that they write in the titles in the reverse direction. On the other hand, not a single case appears in which the bottom-to-top method of reading is combined with the habit of writing titles from top to bottom.

If space permitted it would be instructive to publish all of the individual comments made in reply to questionnaires. Some have already been summarized in our introduction to the problem. There seems to be without question an individual difference in the matter, with the majority of habits formed in favor of tilting the head to the left, making the bottom-to-top reading probably the more agreeable one. At best many consider the practice a necessary evil and, as one well-known psychologist has it, one would "vastly prefer any kind of makeshift in the way of horizontal abbreviation which would obviate the necessity of straining one's eyes to the required position in order to read the vertical type."

Summary and Conclusion: It will be seen from our studies that, so far as the rapidity of reading is concerned, there seems to be no pronounced difference in favor of one direction or the other. With certain factors added, such as height of shelf, position of the book to the right or to the left of the observer, individual habits, and above all, individual preferences, especially as these are emphasized in our verbal reports, then there appears a significant margin of choice in favor of the bottom-to-top direction. Further experiments investigating the period just before reading and possibly also the period after reading should be planned and introspections recorded.

REPLIES TO THE QUESTIONARY

Since the comments, theories, and explanations that were returned with the printed questionnaires would be lost in any statistical treatment of the results obtained, it is better to let them tell their own story without modification. Accordingly there is appended a series of such discussions selected from the entire set of returns. Only those have been omitted whose statement of the point is found in some other quotation and is usually therein better expressed. Many of the statements come from prominent psychologists and other widely known men of science; but because it is doubtful whether we could properly attach their signatures to material thus obtained, we are presenting them only on their intrinsic merits.

"I try to have the legend on the 'backbone' of every publication that is not wide enough to print across printed to read from top to bottom. As my function is more that of the maker of the periodical than of the user or the librarian, I am interested in having all such arrangements meet the convenience of the persons who use them.

The best summary of the argument for top-to-bottom readings is found in H. P. Ward's "American College Catalog," page 79:

"Although some college catalogs are made with the backbone title reading from bottom to top, many are properly printed with the title reading from top to bottom. The reason for this form is that when the catalog is laid flat on a table or desk, front side up, and other catalogs are placed on top of it, it is possible to read the backbone title without taking it out of the pile. The best explanation of this matter would be a glance at a pile of old magazines. It would be far better if the few catalogs whose backbone titles read from bottom to top could be treated as the great majority are, with the backbone title reading top to bottom, for the sake of uniformity of appearance in the Exchange Catalog Shelves of hundreds of institutions and libraries. The librarian customarily passes along a shelf from left to right. reading from top to bottom. He is entitled to some consideration.

It seems to me that the question of uniformity is the important one here."

"When I started in to print the *Review* I was perfectly shocked to find that the printer had printed the title on the back of the magazine from bottom to top. It looked all wrong to me and yet the printer declared that that was the usual custom. I told the usual custom to be hanged; the *Review* was going to suit my aesthetic taste, and so it follows it from top to bottom."

"(a) I find I incline my head more readily to the left than to the right. (b) Predisposition to read from left to right favors printing titles from the top toward the bottom because when the book is laid flat on the table or book-shelf with the front cover up, the printing on the back is then right-side up and reads from left to right. Perhaps the disposition to read from top to bottom also favors the printing of the title in this way.

In spite of the considerations mentioned in (b), I prefer the reading from bottom to top. In this connection, it may be worth while pointing out that this is the practice of the government printing office—at least it is so in such bulletins as fall under my eye as I write this."

"I return herewith your outline and in this connection wish to say that I have gone over my private library including many thousand pamphlets and as nearly as one can determine by a rapid examination the following is true of the publications which have printed labels on the backbone. Older journals printed in America have the label running from bottom to top, where the same periodical in the last dozen years has changed its habit. The same is true of government publications issued in the Philippines. However, those printed in Washington, namely the Geological Survey and the United States National Museum, have consistently followed the rule of beginning the line at the bottom and printing towards the top. All of the English periodicals to which I referred have the titles on the backbone started at the bottom and reading towards the top. All recent French (one exception), German (one exception), Italian and Russian publications make the title read from the bottom towards the top. In old German publications this seems to have been the exceptional method and of the few I had almost all had the title printed in the opposite direction."

"Recent scientific publications of medical character printed in this country have the backbone title reading from the top towards the bottom."

"I found on attempting to study the shelves, I approached them always in such a way as to stand at the right and then it was natural to read from the bottom towards the top following direction from left to right. When I tried to stand at the left in which it was possible to read easily from the top to the bottom, it required considerable effort to push my head into the proper position and it was not natural to handle the books because in separating them one always looked at the back of the pamphlet, whereas in approaching from the right one could pull the books apart and the eye fell naturally on the front of the pamphlet. It seemed to me that there was not any difficulty in inclining the head towards one side rather than towards the other. I am not sure that habit is the factor involved but my experiment lead to the distinct feeling that one way was natural and the other not."

"In a filing drawer where pamphlets are grouped back up, it is very inconvenient to have the title read from top to bottom. Come over to see my library some day."

"I believe this habit of reading from below upwards may be connected with that of writing with the paper tipped upward at the right. It would be very awkward to write with paper tipped downward at the right; that would demand a cramped inward movement of arm, whereas inclining paper upward at right gives a free outward movement of arm."

"In reading the titles of volumes on shelves printed lengthwise of the volume I always stand on the left side of the volume and the head is inclined to the right side. I find it difficult to stand on the right side and to incline the head to the left. All geological publications of United States and Canada, British colonies and nearly all British print from bottom to top. Perhaps this may be reason for my preference."

"It would be inconvenient to write from bottom to top as I hold book in left hand and it requires less energy to turn it into position to write bottom-top than top-bottom."

"The 'psychology' of it with me appears to be that when a lot of such things are shelved in alphabetical order by author (or title) I seem to be reading them *down* the pile,—much as I would continue the alphabet *down* onto another shelf; so they resemble a series of alphabetical titles on a printed paper which I read from top to bottom far more readily than I should if they began at the bottom with A and wound up with Z on the top line."

"All narrow columns such as the headings to columns in tables read from top to bottom. This holds true even though the headings are spelled out by single letters. The habit is thus formed of reading downwards. This may seem inconsistent with the common practice of placing tables and cuts that run lengthwise of the page so they read from the bottom as the left hand side of the page. But to read such tables we must *turn the book,* and the most natural method is to turn it 'clock-wise.'"

"My head inclines more readily to the left. I attribute this to the fact that I always have the light come over my left shoulder, and hence usually read with head inclined a little to the left. Likewise, right-handed people write with heads bent to the left."

"I find also that I have had to put labels on a very considerable number of small slim botles and in every case it reads from bottom to top. I naturally pick the bottle up in my right hand by the top and swing the bottom to the left, so the bottom to top label is easily read. I have counted 20 booklets and pamphlets here which have titles lengthwise on the back—all as prepared by the printer. Eight have titles bottom to top and 12 top to bottom. To my mind there is little difference after we get used to either, but uniformity is desirable."

"Titles of books are usually printed at the top, often back of the volume.

The beginning of the lengthwise title should be near the same line as the cross-wise title."

"In searching for books on a shelf, using titles, a man usually works from left to right, and so likes to catch the clue word of a 'back-bone' title on the same level as other titles, without fumbling lower down."

"In my own case, I am quite positive in this matter. Even in so small a matter as inserting a word I write it tilted thus . When going down a shelf of books you naturally follow, instead of backing along, as you cannot do when you read from the bottom up."

"Personally I have a slight preference to turn my head to the left in looking at such titles which would mean printing from bottom to top. I arrange MSS. in folders on that principle. I am right-handed. On the other hand, I am *strongly* of the opinion that all such titles should be printed from top to bottom for the following reason. Unbound magazines are more frequently laid flat than on edge. It is absurd to lay the magazine face down; and it looks equally foolish to see the title upside down on the back. The edge titles of unbound magazines should therefore be printed from top to bottom. Why have one rule for magazines, another for books? A thin book is often laid flat and it is much simpler to have the title page uppermost and the back title upright. On the ground of simplicity I should recommend very urgently that one uniform rule be adopted, namely, top to bottom."

"The only justification, in my opinion, for the bottom to top method of printing titles is the stacking of books and reprints horizontally, rather than vertically, and even this is doubtful value. For, when books are kept horizontal, the book to be consulted must be turned over through an angle of 90° before the title page is readable."

"A right-handed person commonly writes with the lines sloping from lower left to upper right of the visual field to accommodate his forearm movements. Never the opposite slope as far as I have observed. This is reversed for left-handed persons. This gives a considerably greater familiarity to upward reading lines to the majority of persons. My practice is, wherever I am not otherwise constrained by positions on a ladder or other considerations, to turn pages with the right hand and hold a book with the left. This naturally leads to taking a book from the shelves with the left hand. As a matter of economy of effect this is worth encouraging by upward reading titles. The main point is uniformity. We can readily adapt ourselves to either way of printing. Lack of uniformity is disturbing and fatiguing."

"If I incline, not *only* in order to *read,* but *read* and *handle* at the same time, I incline to the left because I handle with the skillful right and support the body with the unskilled left. The conditions are so complex, that it is of little average advantage to use one method of writing titles rather than the other. We might as well decide it by tossing up a coin. But it is of the greatest advantage to have all titles written the *same* way. Maybe one style is already preponderant. Then *that* should be *generally* adopted."

"If a book is lying before you, right side up, opening at right, a title printed lengthwise on back can be read by moving head and tipping to left, with a slight raising of the back of book, *if* title is printed from bottom to top. But if printed from top to bottom, greater movements (changes of position) are required. This seems to me to be the only fact indicating which is the 'normal' method of printing. Either method would be satisfactory, if made universal. One would as easily form the habit of looking one way as the other along the shelf. I prefer, however the 'normal' arrangement of reading from bottom to top."

"If I were sitting in front of a bookcase at some distance I would prefer that the titles be printed from top to bottom. If I were in front of a bookcase and passing from right to left, I would prefer that the titles be printed from bottom to top. If I were to pass from left to right I would prefer that the titles be printed from top to bottom. I would naturally pass from right to left. If I were sorting through a pile of reprints placed in front of me, top cover up, I would prefer that the titles be printed from bottom to top."

"In reply to your inquiries of February 12th, I write to say that the practice to which you refer always fills me with suppressed rage, for unless the book concerned happens to be at the level of my eyes, I find myself attempting to stand on my head in order to compass the necessary reading. My impression has been that I find this process less distressing when the title is entered from top to bottom than when in the reverse form; but either practice has always seemed to me an invention of the Evil One. I vastly prefer any kind of makeshift in the way of horizontal abbreviation which will obviate the necessity of straining one's eyes to the required position in order to read the vertical type. Although I have never made careful experimental study of the matter, my general impression has been that if books were on shelves below the level of my waist, I would prefer to have the titles run from the bottom up. With the shelving in my own library this occurs less frequently than the converse way with the books above my waist and perhaps explains my supposed preference for the title running from the top downward."

"My head inclines more easily and automatically toward the left. I read more comfortably with a left-hand inclination. The usual flat position of a book held in front of the face, title page up, brings the reading on the back from bottom to top."

"I slightly prefer inclination of the head to the left, but I am inclined on the other hand to approach a book shelf from the left and this necessitates the reading of titles from top to bottom. Undoubtedly, the habit of reading from left to right affects the situation. I recently noted that when titles of books are printed lengthwise of a page, the orientation differs. There should certainly be uniformity of practice in this connection. I prefer to have the lines begin at the bottom of the volume extending thus from bottom to top. Evidently the conditions which influence me in this case are somewhat different from those in the case of the title on book or volume. If instead of reading titles on a book shelf, I lift a volume from the table to read lengthwise title, I very much prefer to read from bottom to top."

"In reply to your questionnaire with regard to printed titles on the backs of books and periodicals I beg leave to say that I find on examining my preferences that I prefer a title that reads from the bottom to the top. I find that my method of approaching the bookcase is such that I naturally tip my head toward my own left hand and stand in such a position that I read up rather than otherwise. I did not realize that I had the preference as fully as I find that I have. I am quite right-handed and do not know of any general considerations that would have prompted the development of this habit. I call your attention to one fact, well known to oculists; there is a tendency for the head to be bent so as to bring the plane of normal fixation of the two eyes into a position where there will be the least muscular strain on the eyes. The neck muscles in this way coördinate in making eye adjustment."

EXPERIMENTS IN SOUND LOCALIZATION[1]

By C. A. Ruckmick

It is not necessary to give the historical background of the problem since that has already been given in several recent studies.[2] It should be said, however, that new interest was aroused concerning the investigation of sound localization because of very urgent questions that arose in connection with the war, questions which indeed made both the physicists and the psychologists realize the dearth of material on the subject. For example, practically nothing of scientific value had been done in either of these sciences with the problem of sound localization through mediums other than air. The need for accurate and rapid detection of sapping activities on the part of the enemy and the necessity of localizing with equal precision and speed the presence of enemy submarines made it clear that we should know facts concerning the localization of sound through the solid earth and through water, in addition to more detailed information concerning the localization of aeroplanes in flight. Accordingly, both physical and psychological scientific societies undertook, through specially appointed committees to make further specific investigations into these matters.[3]

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[1] These experiments were undertaken by a group of students doing advanced or graduate work in the Department. The experimenters who were responsible for various sections are: Miss Harriet Anderson, Miss Hilda Kohl, Miss Anna Polkowski, and Mr. A. W. Gross. To these and to the many observers, the compiler of the results wishes here to give suitable recognition.

[2] One of the best summaries of the literature is given in Klemm, O., Untersuchungen über die Lokalisation von Schallreizen, *Arch. f. d. gesam. Psychol.,* 1918, xxxviii, 71-114.

[3] Besides coöperation with the physicists, through consultations and the lending of apparatus, the author undertook to contribute his share of the work of the Committee on Audition, appointed by the American Psychological Association, by supervising three or four pieces of research in this field.

I

Without going into the controversy regarding the question of the binaural ratio, we attempted to indicate the influence of relative intensity in the localization of sound under conditions that should guard against certain psychological errors of which experimental research on the part of physicists is not always free. In particular we attempted to duplicate, in principle at least, the work of Myers and Wilson,[4] two investigators who seem not sufficiently to have considered errors of this sort.[5]

Apparatus: We used two quiet rooms in the psychological laboratory, one of them a large dark room (Fig. I). In the outer room, a large wooden box enclosed a Stern variator (No. 2, 150 vd. to 300 vd. Opposite the lip of the instrument a large eight-inch tin funnel was inserted, with its outer edge bound by rubber and directed towards the variator. Its narrow orifice was extended by means of rubber tubing ¾″ in diameter to the operating table in the inner dark room. The Stern variator was set at three different pitches in the course of the experiment, 193 vd., 200 vd., and 217.5 vd. Rubber tubing from the compressed air service piped into the building conducted air through a reducing valve to the intake of the Stern variator. The inside of the box was thoroughly stuffed with cotton waste and the outside of the box was wrapped with deadening material made of seaweed. All openings between the two rooms were tightly sealed, and several observations were made to determine whether any sound could be heard in the inner room when the valves were closed and the Stern variator was operating. The large rubber tubing passed through a carefully packed opening in the wall between the two rooms to two sliding valves. Before coming to these valves the tube bifucated through a glass Y. The sliding valves were so arranged that the full diameter of the

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[4] Myers, C. S., and Wilson, H. A., The influence of binaural phase differences on the localization of sound, *Brit. J. of Psychol.*, 1908, ii, 363-385.

[5] The author would like to see some of the experiments on the intracranial localization of sound repeated under rigid conditions. It seems remarkable, for example, that (in our experiments) no localization was reported, as referring to either ear, or to any position "in the head."

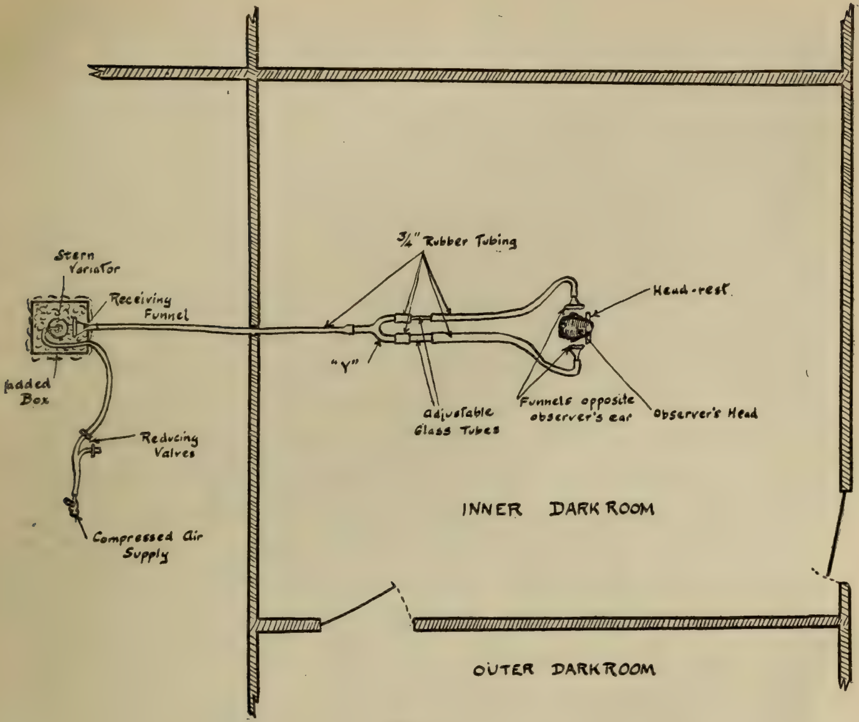

FIG. I

tube was maintained but could be reduced by the experimenter. Since the question arose in the preliminary series whether a valve of this sort might not, when partly closed, produce eddies in the current of air, later in the main series we used glass tubes of nine different diameters, .15, .2, .4, .42, .45, .6, .65, .9, and 1.1 cm. These were always used in pairs, one on each side of the Y. From this point on a pair of ¾″ tubes was continued for about 10′ and ended each in a small 2″ tin funnel, the outer edge of which was bound in rubber. The funnel on each side was held in a standard opposite the ear of the observer, and the observer's head was fixed in a head-rest.

Procedure: It must be understood, of course, that none of the observers ever knew, in the course of the experiment, the arrangement of the apparatus or the nature of the problem. The observer was led blindfolded into the dark room and great care was exercised by the experimenter that, as he sat down and inserted his head in the head-rest, his head should not touch either funnel. The four observers who took part in the experiment never realized that two separate sounds were coming to their ears, and, in fact, when subsequently told of the conditions, they could hardly be persuaded to believe the situation to be as described.

When the observer had been seated he was instructed to visualize a sphere with his head at the center and the zero point directly in front, and to keep clearly in mind the quadrants to the left, right, above, and below. He was further instructed that a sound would be produced in the room and that he was to localize this sound in terms of the imaginary sphere and by such designations in the sphere as would enable the experimenter to record the results. In some cases these symbols were adjusted to the preferences of the observer. He was also required to estimate the distance that the sound was away from his head.

The reports of the Obs. were taken down by the experimenter on a mimeographed blank which designated the number of the trial; date; observer; position left, right, above and below; intensity; distance; and "remarks." There were over 650 trials recorded and results tabulated. In the preliminary series, nine positions of the valve were marked on each side, and a haphazard series was arranged in advance to include the various combinations of these positions. The same plan was followed in the main series, in which the glass tubes were used in place of the valves.

It is clear, then, that since the length of the tube on each side was kept precisely the same, and since the only change introduced was a change in the opening through which the sound waves passed, there could be no modification of the wave save amplitude, a modification calculated to produce a difference of intensity for the two ears. This is especially true of the second part of the investigation in which eddies were avoided.

The experiments were conducted during the academic year of 1917-1918 and during the summer session of 1918, in the Psychological Laboratory at the University of Illinois. The observers were well trained advanced students in the department.

Results: In the preliminary investigations the results do not show marked correlations with the different positions of the valves unless the opening on one side was much greater or much less than on the other. We find, however, that the summation of apertures had a marked effect on the distance of the sound. When both openings were large the sound was reported as much nearer than when they were small. The modes varied respectively from a distance of 20 ft. in the case of one-ear presentations to a distance of one foot in the case of two-ear presentations.[6] Another way of illustrating this fact lies in percentages obtained for loud sounds, *e.g.,* 60% of the two-ear presentations were reported as "loud" or "very loud," while only 42% of the one-ear presentations were so described.

While our results on the matter of the binaural ratio are preliminary and tentative, a study of the individual tables points to the conclusion that there is a tendency to localize a sound more and more toward the median plane as unity in the binaural ratio of intensity is reached. The data on this point are not as yet sufficiently free from the errors of the ordinary "sound-cage" procedure to permit of precise mathematical formulation. One of the chief difficulties which confront the investigator in this field is the inability of the observer faithfully to reproduce his judgments in an imaginary sphere either by the visualization method or by the pointing method. But expressed in percentages, there are indications in our experiments that the ratio of intensities, as transmitted independently to the two ears, was the controlling factor in the localization. Eighty-six per cent. of the sounds presented to the two ears with unlike intensity were localized on the side of the greater intensity. Sixty per cent. of the sounds produced with equal intensity were localized in the median plane. It must be remembered, of course, that the fewest errors occurred when the difference in intensity was marked and that some sounds with a moderate difference in intensity were localized in the median plane. Although all the observers were tested for acuteness of hearing and fell well within the normal, there was still an individual difference in the results of our experiments, due largely, it is assumed, to variations in ability to designate the localization.

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[6] This ratio is somewhat larger than the summational effect reported by Klemm, *op. cit.,* 79, but, of course, not so precisely obtained.

Conclusion: On the basis of our results we can not, of course, speak with absolute assurance concerning the rôle of binaural intensity in sound localization. Our experiments, confined to a limited number of observers and subjected to the usual methodological difficulties, convince us, nevertheless, that no factor outside of intensity could be held responsible for the results obtained, and that the results themselves were far above the figures for chance variation. We should like to see the experiments repeated under better conditions, perhaps out-of-doors, and with a larger number of observers, but with a strict adherence to the procedure "without knowledge."

II

Investigations were also under way regarding the difference in the ability of an observer to localize sound due to the position of his body. One does not have to recall here the questions that have arisen in the literature concerning the dependence of sound localization on the semicircular canals and the muscular adjustments due to the inner ear. It was assumed that, if the reflecting surfaces in the room could be kept uniformly constant for each position, any differences in sound localization within a sound-cage would be due to these disturbances.

Apparatus and Procedure: In our normal series we placed the observer in a sitting position within the standard form of Stoelting sound-cage whose telephonic click was modified by introducing a vibrating induction coil. The telephone receiver was connected to the secondary circuit of this coil. Over 400 observations were made including the series in the sitting position. In connection with the other positions, a couch was provided and so braced that the head should be projected beyond one end and that it should then be approximately at the same point as it was when the observer was in the sitting position. An equal number of observations were taken with the observer lying on his right, on his left, on his back, and with face down. The room used was the largest in the laboratory and, so far as possible, reflecting objects within the room were removed.

Results and Conclusions: In calculating the errors for each position we find no conclusive evidence of any marked differences due to inclination of the body. We eliminated, however, from each series the first five judgments on the ground of inaccuracy due to making judgments in unaccustomed positions. This part of the investigation also might well be repeated under better conditions and with more observers. Care must be exercised, of course, that the couch used does not itself add new reflecting surfaces of any consequence and that it is, at the same time, fairly comfortable for the observer.

THE INTENSIVE SUMMATION OF THERMAL SENSATIONS

By ANNETTE BARON and MADISON BENTLEY

I

When we plunge the fingertips into water there usually arises a sensation of cold or of warmth which seems gradually to increase in intensity as more and more of the hand is immersed in the liquid. From this common experience the conclusion has often been drawn that the intensity of a temperature sensation is a function of the size of the stimulated area.

E. W. Weber, who long ago cited the instance,[1] believed that the impression of temperature felt when a surface is heated or cooled was due to the summation of the intensities of the several sensations aroused. On the other hand, Stumpf,[2] arguing from the analogy with auditory sensations, later expressed a doubt concerning the actual intensive summation among sensations of cold and warmth. From his studies on tonal fusion, he concluded (1) that the intensity of a sound is not augmented but rather diminished by the presence of other simultaneous sounds; and (2) that a tonal complex is no stronger than its strongest constituent. There is, then, as he thinks, no real summation of intensities.

Now let us consider the possibilities in the case of temperature. Stumpf himself suggested three alternative explanations of this apparent augmentation of temperature as the hand is plunged deeper and deeper; (1) the confusion of spatial extent with intensity, (2) the stimulation of more sensitive regions as the hand is gradually immersed, and (3) an augmentation of sensory feeling.

Besides these three possible substitutes for a real intensive summation, Barnholt and Bentley,[3] attacking the problem in the laboratory, have suggested (4) adaptation, (5) the presence or absence of organic accompaniments, (6) the confusion of pressure with temperature, (7) the addition of individual organs of higher tuning, and (8) a difference in cutaneous conduction in large and small areas.

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[1] Weber, E. H., in Wagner's *Handwörterbuch der Physiol.*, 1846, iii, 2, 553.

[2] Stumpf, C., *Tonpsychologie*, 1890, ii, 446.

[3] Barnholt, S. E., and Bentley, M., Thermal intensity and the area of stimulus, *Amer. J. of Psychol.*, 1911, xxii, 325-332.

These experimenters applied temperature points to areas and to individual organs for cold and warmth, on the forehead, hand, and forearm. To come to a decision among all these possible explanations of the simple observation from which they set out, they devised four different methods.

The first method consisted in the immersion of the fingers to graduated depths. The larger surfaces were reported as giving more intense temperatures, thus confirming common observation; and, moreover, the introspections showed the judgment to be really based, in part, upon intensive differences.

In order to simplify the conditions, a second method was employed in which a series of five flat-ended brass cylinders with diameters ranging from 1.4 cm. to 3.3 cm. was applied to the skin. Again the larger surfaces led to reports of more intensive colds and warmths.

But to make sure that mere size of the stimulated area was not responsible for intensity, a third method introduced comparisons between graded areas of high and low sensitivities. The same cylinders were used under the procedure of "paired comparisons." The discovery that a small area which returned a vivid, bright cold or warmth could be made equal, for sensation, to a large area of low sensitivity, made it evident that not extent but tuning was the primary condition of the intensive judgment.

The factor of thermal conduction through the skin was disposed of under the fourth method. Differences of conduction were eliminated by stimulation of individual organs chosen at such distances from each other as to eliminate conduction of the stimulus through the dermal tissues. First, these temperature organs were compared with each other (1) in pairs and (2) in setting one against two others. There was found a considerable difference of tuning between the different organs. In the second part of the final method, the experimenter observed whether reenforcement of one sense-organ by another occurred. The thermal sensation produced by stimulation of a single organ was compared with the sensation resulting from the stimulation of this same organ plus another organ of higher or lower tuning. The two organs seemed to have an intensive advantage over one only when one of them was superior in tuning. That is to say, no convincing evidence of summation was found; instead, the intensity of the sensations seemed to be determined only by the most highly responsive spot under stimulation.

Finally, Barnholt and Bentley demonstrated, by the use of artificial membranes simulating the skin, that the large stimulus may influence intensity of sensation by the mechanical process of cooling the skin under conduction. The skin is actually colder under the extensive stimulus than it is under the stimulus of smaller extent.

II

It has seemed desirable to repeat some of the methods of this experimental study, partly for the sake of verification by a larger number of observations, partly to modify the procedure in certain important respects, and partly also to consider the divergent results of another research which will presently be described. The following methods were adopted.

Method A. Four organs of different tuning for cold were mapped upon the volar forearm within an area 2 cm. square and designated by letter, "w" (weak), "m" (moderate), "i" intense), and "I" (very intense).[4] They were stimulated with blunt-pointed temperature cylinders kept at 0°C. The procedure was as before (Method IV, above), except that one organ was kept throughout a whole series, first being compared in both temporal orders with each of the other organs taken by itself, then with two of them given simultaneously, then with three, but never with itself.

In Table I the letters A, B, and C denote observers, and Tl. is

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[4] A long preliminary series served to determine the decided graduation in tuning of the four organs selected.

TABLE I

		m			i			I		mi			iI	mI		wI	miI		
	Obs.	G	L	=	G	L	=	G	=	G	L	=	G	G	=	G	G	L	=
w	A	3		1	3	1		4		4			4	4			3	1	
	B	3	1		3	1		4		4			4	4			3	1	
	C	3		1	4			4		3		1	4	4			4		
	Tl.	9	1	2	10	2		12		11		1	12	12			10	2	
		wi			i			I					iI			wI	wiI		
m	A	4			2		2	4					4			4	4		
	B	4			3	1		4					4			4	4		
	C	4			4			4					4			4	4		
	Tl.	12			9	1	2	12					12			12	12		
		wi			wm			I						mI		wI	wmI		
i	A				3		1	3	1					4		4	4		
	B				3		1	4						3	1	4	4		
	C					3	1	4						3	1	4	2	2	
	Tl.				6	3	3	11	1					10	2	12	10	2	
		wi			wm					mi							wmi		
I	A	4			3		1			4							3	1	
	B	1	3			4				3		1						3	1
	C		3	1		4					4						3		1
	Tl.	5	6	1	3	8	1			7	4	1					6	4	2

the total for each set. The entire number of comparisons is 264. The letters at the left of the table indicate the cold organ —weak, moderate, intensive, very intensive,—which is compared with one or more of the other organs, written horizontally across the table. Thus "3" written near the upper left-hand corner means that Obs. A three times judged the cold from the organ of moderate tuning (m) to be greater (G) than the cold from the weakly tuned organ (w, at the left). The relatively large number of "greater" (G) judgments where each organ is compared with *one other* of *higher tuning* (w with m, i, or I; m with i or I; etc.) clearly establishes the wide and constant difference in sensational intensity with which our four organs responded throughout the experiments. An inspection of the results will make it apparent that the member of the comparison which contains one or more ogans of high tuning is nearly always judged to be more intensive (G) than the other number.

In order to guard against the variable errors of time,—expectation, habituation, fatigue, and the like,—the one-to-two and the one-to-three judgments were all repeated with all Obs. in a mixed order of presentation with a selection by chance. This control-series numbered 128 additional comparisons. It led to 100% of "greater" judgments (1) when 2 or 3 organs of higher tuning were compared with 1 weaker, and also (2) when the single organ stood intermediately with respect to 2 or 3 others. In those cases where an intensity from high tuning was compared with two intensities from low tuning the L-cases were only 4 out of 24. These results, then, are as unequivocal as the others. Their significance will be more apparent from Table II, where both sets are combined, with the omission of the one-to-one comparisons. Here the intensity from one organ is always compared with 2 or 3 organs of different tuning. The G, L & = judgments are always set down in terms of the plural organs.

TABLE II

	G	L	=	T'ls
2 organs of HIGHER tuning	79	0	1	80
3 organs of HIGHER tuning	19	1	0	20
1 organ of HIGHER and 1 organ of lower tuning	78	0	2	80
1 organ of HIGHER and 2 organs of lower tuning	18	2	0	20
2 organs of HIGHER and 1 organ of lower tuning	20	0	0	20
2 organs of lower tuning	25	34	21	80
3 organs of lower tuning	14	4	2	20

The Table reads thus: the presence of one or more organs of higher tuning, leads, in the comparisons, to the judgment "greater intensity" in 214 out of 220 cases; while the comparisons with organs of lower tuning alone leads to "greater" judgments in only 39 out of 100 cases, and in only 16% in the second, most reliable, set of experiments. But if the *number* of temperature organs stimulated, instead of their *tuning,* had determined the judgments, then there should have been as many G-cases in the last hundred as in the first hundred; and again, these cases should have run with the plural organs in the middle group.

These last figures show even more clearly than the corresponding results of Barnhold and Bentley the essential dependence of intensity upon tuning. There is, however, left the fact that plural organs of *lower* tuning than the standard do give rise to G-cases in larger number than the L-cases from plural organs of *higher* tuning. There is still left the implication that number does play a minor rôle in the determination of intensity. This implication becomes explicit in the experiments of Siebrand, which were published[5] at about the same time as the Cornell Experiments. Although Siebrand did only a few experiments and although he neglected the factor of tuning, we have thought it well to repeat his methods under the necessary precautions.

Employing the flat end of a brass rod of 12 mm. diameter, Siebrand (p. 213ff) stimulated in succession two areas of like extent within which he had previously determined the number and position of the cold organs. The surface including the greater number of organs he and his Obs. sensed as colder in 80-90% of his (60) cases. In concluding that intensity depends upon number, however, he overlooks the fact that the greater the number of receptors the greater the chance of including at least one organ of high tuning. Our own experiments follow.

Method B. i. Comparisons between two areas of the same extent. A square area, 2 cm. x 2 cm. was laid off upon the volar forearm of the observer. The number and position of the cold-spots were determined by means of blunt-pointed cylinders. When the organs had been accurately localized upon the square their tuning was established by comparisons. Four degrees of tuning were used; w, m, i, and I. The experimenter, using only the flat end of a temperature cylinder cooled to a temperature of 20°C. (Siebrand used 18°-20°), compared two surfaces of equal extent within the square, which included different numbers and different tunings of cold organs. As many comparisons were made as were possible without interfering with other organs. Two series of comparisons gave us the following results. The small letters indicate as before the tunings of the organs compared for intensity.

TABLE III

1st Series:		Obs. C.	2nd Series:		Obs. S.
1 w	<	w m m m i i i	1 w	<	w m m i
2 w m	<	w m m m i i i	2 w	<	w w m m m i
3 w m	<	m m m i	3[w m	<	w m m m]
4 w m i	<	m m m i I	4 w w m	<	m i
5 w m m i	<	m I	5 w w m	<	i
6 w m m i i	<	m m I	6[w i	<	w w m m m]
7 m	<	w m m i	7[i	<	w w m m m]
8[m I	=	w m m i i]	8[i	<	w w m m m]

---

[5] Siebrand, Untersuchungen über den Kältesinn, *Zsch. f. Sinnesphysiol.*, 1911, XLV, 204-216.

In 11 of the 16 cases a greater intensity is reported for the member which involves an organ of higher sensitivity, the number of components within this member being sometimes more and sometimes less than the other member. In all the 5 remaining cases (in square brackets) the greater intensity appears only when a much larger number of like or slightly lower organs enter into the comparison.

ii. Comparison between a point and a surface. Comparisons were then made in the same way as in the preceding method, except that we now alternatively used the blunted point and the flat end of the temperature cylinders. The results of the two series of experiments are reported in Table IV.

TABLE IV

1st Series:	Obs. C.	2nd Series:	Obs. S.
w w	< m	w m m	> w
w m	< i	w m m	< I
w w m	< i	w i	< I
w w w m	< I	w w m i	> i
w m i i	> i	w m m i	> w
w m i i	> i	w m m i i	> I
m i	> w	w i I	> i
m i	> i	m m	< i
m i	< I	m m i	> i
w m	= i	m i	> I

In 8 of the 20 cases in Table IV we find exceptions to Siebrand's rule that thermal intensity is a function of the number of organs excited, *i.e.*, in these 8 cases the more intensive sensation is produced by the stimulation of a single organ of higher tuning when compared with an area which includes a plurality of spots of lower sensitivity; and in 9 of the 12 remaining cases the "stronger" group contained an organ at least equal in tuning to the single organ.

Although we find but little support for Siebrand's contention, there does here again appear a slight intimation that the number of components does exert an influence upon the judgment of intensity. Let us further refine our method to discover, if it is possible, whether, and under what conditions, the influence of number does obtain.

Method C. In the second part of their fourth method, Barnholt and Bentley have observed the effect of adding an organ of unlike tuning to one already under stimulation. We have adopted the same procedure, but for another purpose. We wished to discover whether the slight tendency to connect number and intensity was due to the lack of analysis of fused or colligated members. To this end we have distinguished between "total-impression" and "analysis." With the same application of stimulus, we have varied the instruction to our observers. Under (i) below we give our results where the Obs. was instructed to report any intensive change or difference which might appear, without analysis, under stimulation. Under (ii) the instructions were to attend only to the initial cold, reporting any alteration which might occur in that particular sensation.

i. Total-impression judgments. First a "moderate" cold organ (m) was stimulated for 2-3 sec. by a blunt temperature cylinder brought immediately after drying with cotton wool from an ice-bath at 0° C. After an interval of 2-3 sec., the same stimulus was repeated, this time with the addition of a like stimulus applied to an "intensive" (i) or a "weak" (w) organ lying within the radius of 1½ cm. The results in Table V include 110 comparisons for Obs. A, B, and C, and 72 comparisons for a highly trained Obs., M. The figures are percentages. The letters MI and MW give the tuning of the second member in the comparison.

TABLE V

Total impression: with interval: Obs. A, B, C, and M. M with MI or with MW

		G	L	=	?	T'ls
Obs. A, B. and C	MI	58	0	40	2	100
" M	MI	70	2	14	14	100
Obs. A, B, and C	MW	21	3	67	9	100
" M	MW	14	33	42	11	100

The results agree with those in Table II. The addition of "I" leads to a large number of "greater" judgments, and the addition of W to more "less" and "equal" reports. The reduction of "M" under repetition, due to physiological adaptation, doubtless tends to change the whole distribution of cases; but this factor should be constant in both halves of the table.

In order to make still more decided the difference between total impression and analysis, we repeated the last experiment, except that now we continued the M-sensation by holding the temperature cylinder in place throughout the interval and also as long as the second member (MI or MW) endured. See Table VI, which includes 162 cases for A, B, and C, and 72 for M.

TABLE VI

Total impression: without interval: Obs. A, B, C, and M.

		G	L	=	?	T'ls
Obs. A, B, and C	MI	70	0	26	4	100
" M	MI	75	3	16	6	100
Obs. A, B, and C	MW	8	1	85	6	100
" M	MW	14	19	53	14	100

The results are similar to the last preceding, save that now MI gives more G-cases and MW more equal-cases.

ii. Analytical judgments. The instructions to attend only to the initial cold (M) and to report only an intensive change which might occur in this sensation when I or W was added led to a new distribution in the judgments. Table VII is based upon 90 comparisons for A, B, and C, and 144 for M, under this instruction.

TABLE VII

Analysis: without interval: Obs. A, B, C, and M.

		G	L	=	?	T'ls
Obs. A, B, and C	MI	35	0	62	3	100
" M	MI	15	0	77	8	100
Obs. A, B, and C,	MW	2	0	94	4	100
" M	MW	6	1	92	1	100

It appears that, under analysis, the equal-judgments notably increase. Intensive increases are still reported (though less frequently) when the organ of high tuning (I) is added; but almost never when the organ of low tuning (W) is added. The decreases almost entirely disappear. The tendency is for M to remain unchanged. Obs. M, whose results are most significant on account of his long training in analysis, was encouraged to make as full an introspective report as he could. A closer scrutiny of his equal-cases will throw further light upon the integrity of the cold sensation.[6] This Obs. found that these cases fell into four classes, to-wit: (1) equal-without-change under addition of I or W (tabulated below as (e), (2) equal-with-an-undefined-addition (e+?), (3) equal-in-the-presence-of-a-stronger cold sensation (e+str.), and (4) equal-in-the-presence-of-a-weaker cold (e+w). The distribution (percentages as before) for Obs. M into these four equal-classes is indicated in Table VIII.

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[6] Cf. Piéron, H., De la discrimination spatiale des sensations thermiques. Son importance pour la théorie générale de la discrimination cutanée, *C. r.*

TABLE VIII

Equal-cases (121): Obs. M

	e	e+?	e+str.	e+w	T'ls
MI	27	13	53	7	100
MW	60	21	9	10	100

Thus it appears that although adequate analysis usually (121 in 144 cases) reveals the unchanged initial cold, the addition of a stronger thermal quality is more frequently (53%) noted (*Bemerkt* is Stumpf's term, *loc. cit.* p. 278) than is the addition of a weaker cold (10%), and that a corresponding excess of plain "equals" is shown where the second (added) stimulus excites an organ of *low* sensitivity (60% and 27%). It seems likely (though the matter calls for more explicit treatment) that this result simply exemplifies the fact that the intensive attribute is so closely bound up with attributive clearness that the addition of a stronger member has a more profound effect—other things equal—upon a complex than the addition of a weaker member.[7] The especial significance for our study of the analytic judgments is that the slight tendency to judge as "greater" the temperature (cold) from plural organs is due almost wholly to the tendency to judge in terms of the total impression (as Stumpf found in

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Soc. de biol., 1919, lxxxii, 61-65. By dropping water upon the skin, P. excited "pure" thermal sensations (*i.e.*, without pressure). He found the limen for discrimination of locality to be relatively small, 10-15 mm. Most of our *added* stimuli (I or W) fell at approximately this distance from the initial stimulus (M).

[7] The reader will recall that Wundt's doctrine of the "intensive fusions" accords the chief rôle to the most intensive component. The classical instance is the fundamental in the simple clang or musical note. (Wundt, W., *G. d. physiol. Psychol.*, 5th ed., vol. ii, 1902, 418). Cf. the experiments of Bentley upon clearness and intensity in Titchener, E. B., *Lectures on the elementary psychology of feeling and attention*, 1908, 361ff.

the case of tonal complexes, *Tonpsychol.*, ii, 424f). But we cannot solve the problem of thermal increments by reference to total impression alone; and when we analyze, we discover that the thermal quality carries its own intensity in spite of the presence in mind of other sensations of the same mode.

SUMMARY

I. Our experiments support the view that no fixed dependence obtains between thermal intensity and the size of the stimulated area. The apparent and alleged dependence is chiefly explained by reference to the fact of "tuning" of the receptor-organs. Siebrand's contention that thermal sensations are "summated" within the area of stimulation is not substantial because he neglected this cardinal fact.

II. The question of summation demands a more refined method than has yet been used. Barnholt and Bentley have called attention to obscurity and confusion in the statement of the problem and also to various misleading forms of the stimulus error. We have added the distinction between analytic judgments and judgments of total impression, apprehending the necessity of instructing the observer.

III. Aside from the factor of tuning, we have referred the tendency to report as "greater" the cold from two or more organs when compared with one, first, to the judgment of total-impression, as opposed to the judgment based upon explicit analysis, and secondly, to the fact that the most prominent member in a fusion occupies a special prominence, which tends to obscure the other members. Our experiments furnish no evidence of a true summation of sensational elements.

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The Definition of Intelligence in Relation to Modern Methods of Mental Measurement

BY

J. LEROY STOCKTON, Ph.D.

Vice President and Head of the Education Department, State
Teachers' College, Santa Barbara, California

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IV

THE DEFINITION OF INTELLIGENCE IN RELATION TO MODERN METHODS OF MENTAL MEASUREMENT.

INTRODUCTION

I. Necessity for Establishing a Clear Psychological Setting for the Problem of Intelligence.

Probably all will agree that the problem of intelligence belongs in psychology. Naturally, therefore, one would at first thought feel justified in discussing intelligence in terms of mind, consciousness, and other popularly used psychological terms. There have been times in the history of psychology when this could have been done without raising any question; but even minor excursions into modern psychology show that the leaders in that field are fundamentally divided by different concepts and terminologies. They do not agree as to what mind is. They do not even agree as to whether psychology should assume the existence of mind, or, if it exists, whether psychology should make any attempt to determine its nature.

Hence the student of intelligence is forced to review current psychological theories and to decide as to the attitude which he, himself, shall take. Otherwise any conclusions to which he may come, and any arguments which he may base upon the conclusions, are likely to prove abortive, due to a mere misunderstanding of terms.

The situation is similar to that raised by the ancient dispute as to whether there would be any sound at Niagara if there were no ear there to hear it. The argument must result in endless debate unless one stops to ask whether sound is to be defined in terms of physics or in terms of psychology. This illustration merely points the observation that since the intelligence problem is at bottom a psychological problem, any attempt to deal with it constructively must use psychological terms with carefully considered and defined meanings. Thus the later argument can be saved from becoming hopelessly at cross purposes.

Two sources of confusion in modern psychological terminology are (1) the term mind or consciousness, and (2) faculties, or functions, of mind. It is desirable that the points of view concerning these be carefully discriminated, and definite ones selected. This is not to be done with the idea of settling the matter once for all; but rather with the idea that although the reader may disagree with the view chosen, he can at least follow the argument of this presentation without confusion.

An attempt will therefore be made in Chapter I to analyze the current views of mind and of its functions, and later to locate the intelligence problem in relation to these views.

II. Recognition of Types of Research.

There was a time when what was known as psychological research was mainly speculation. One could sit down in seclusion, evolve theories, and record them as his contribution. The theories did not need to have much relation to evidence; and they were in fact not often anchored to anything in particular. They systematized themselves with reference to themselves, and remained essentially a closed circle. Then came the era of scientific experiment, and with it the demand that research cease to be speculative and become quantitative. It must observe, record, and systematize facts which had not up to that time been so handled by anyone else. It must make a genuine quantitative contribution to human knowledge. The demand for this quantitative type of research did not carry with it an absolute ban upon philosophical theorizing; but it did insist that theories must accord with facts, in so far as the pertinent facts were known; and that new quantitative researches should always be engaged in turning up additional facts, with which facts the theories must be kept in line. The real research lay in the development of the new facts.

Such is now the prevailing view. But it may be pointed out that after such research has proceeded to a certain point, its own success develops the necessity for another type. To make this clear one has only to call attention to the fact that as experiment after experiment piles up endless facts in a given field certain complications inevitably arise. This is particularly the case in the rather intangible field of the social sciences. The results of some experiments confirm each other in whole or in part; some are mutually contradictory; while some are difficult to bring into any kind of relation with others.

When the mass of the material on a given problem has grown to large proportions, and still the solution seems as far away as ever, it is time to take account of stock. It is time to attempt to find in the tangle a general trend which may point the way to a more profitable line of attack. That is, research is needed which is a search for organization within the products of other researches. This type of supplementary research requires that a rather exhaustive study of the field be made; that efforts of different investigators be brought into relation to each other and to principles involved; that irrelevant details be excluded and relevant ones emphasized; and that the whole be brought to a focus.

III. THE RELATION OF HYPOTHESIS TO RESEARCH.

The research for organization among the products of unrelated researches furnishes the basis upon which extensions may be attempted. Such a study of conditions makes it possible to formulate a guess as to certain other things which are probably true, but which have not yet been adequately proved. This guess, controlled by a consideration of the investigations which have preceded, is an hypothesis. Its significance is, or should be, determined by the significance of the previous work, and by the skill with which such work has been probed and interpreted. To continue quantitative work indefinitely without subjecting it occasionally to such clearing-house methods as result in a clarified and consistent hypothesis is, to say the least, wasteful. But when the revised hypothesis has been arrived at, there then exists a logical demand for new quantitative work which shall put it to the severest test.

IV. THE OBJECTIVES OF THIS THESIS AS GUIDED BY THE CONSIDERATIONS MENTIONED ABOVE.

A. To locate more definitely the problem of intelligence in relation to fundamental points of view in psychology.

B. To use clearing-house methods of research upon the present situation with regard to intelligence in an attempt (a) to establish a definition of intelligence, (b) to discriminate types of intelligence, and (c) to discriminate a pivotal type.

C. To further clarify the situation by relating existing quantitative studies to the types of intelligence.

D. To develop an hypothesis concerning the fundamental nature of the pivotal type of intelligence; and to test this hypothesis by quantitative research.

E. To apply the conclusions to a critical survey of modern methods of mental measurement.

CHAPTER I

FACTORS IN A PSYCHOLOGICAL SETTING FOR THE PROBLEM OF INTELLIGENCE.

I. Psychological views of the existence and function of soul, consciousness, mind, mental states.

The "mind and body" controversy has been a lengthy one, and it is not yet ended. Early psychology was philosophical, metaphysical. It was a speculative study of a consciousness called the soul, whose existence no one questioned. Along with this metaphysical psychology, there naturally appeared an empirical psychology, based upon attempts to describe psychic phenomena through the aid of introspection. Metaphysical and empirical psychology were supplements of each other in that empirical psychology was largely guided by metaphysical views; and metaphysical pschology, on its part, continually used empirical materials. There arose a natural dualism, a contrast between soul (mind) and body (matter). Attempts to escape this dualism led, on the one hand, to the contention that matter was only another manifestation of spirit; or on the other hand to the contention that what was apparently spirit was only another manifestation of matter. Thus there came about a division of psychological thinkers into spiritualistic monists, and materialistic monists.

A hot-bed of discussion of these different points of view is found in the work of Huxley, Tyndall, Clifford, Romanes, etc. The main reason for the break between the old and new views lay in the growing scientific spirit, and in the conception of scientific law characteristic of that spirit. The belief that the world processes rest upon the law of cause and effect, coupled with the belief in the conservation of energy, made it seem impossible that any world of "mind" could "break in" upon a world of matter "locked up in mechanical causation", and change the cause and effect series. Such a breaking in would require the addition of some energy to that already existing in the world of matter, and so would controvert the law of conservation of energy. As philosophers the scientists might hold speculative views of such a possibility, but as scientists they could see no other answer to the dilemma than monism, either spiritualistic or materialistic. Moreover, with science avowedly dedicated to the study of facts which could be verified in the world of things, it is clear how the drift was toward materialistic monism and the elimination of the "soul" from scientific psychology.

There continued, however, to be psychologists who were dualists, who discussed mind or consciousness, and who meant by it something the same as was meant by the metaphysical psychologist's concept of the soul. They continued at least to conceive of a world of mind and a world of matter; and in spite of the scientific difficulties involved, they believed that the former did have something to do with certain changes which took place in the latter. They were forced to this view by their observation of the organism as an "adaptation system". They saw this organism changing its behavior with reference to its environment. That is, they saw that the mechanical systems of prearranged instinctive response did not always run to their apparently inevitable conclusion. Behavior did vary to suit circumstances. Some of this variation, or adaptation, could be explained mechanically by the conflict of mechanical systems or otherwise; but some of it could not. The psychologist, judging certain other things by his experience with himself, believed that adaptation sometimes came about through an effective mental agent acting as a real power of choice between possible systems of action. Thus in his judgment the systems did not always run freely to their mechanical conclusions. He conceived of a mind or consciousness whose specific function was to interfere in those situations which demand behavior for which mechanical systems are inadequate.

But it was necessary to put forth a theory as to how this relationship between the world of mind and the world of matter was possible. There could be but two theories. Either there was direct interaction between the two worlds, or there was parallel action between them. Upon the theory of interaction the immaterial mental agent must leap the gap between it and the material world, and exert itself directly. This theory has not been very popular among the scientists, because it runs directly against the scientific difficulties already mentioned.

Upon the theory of parallel action, however, the question was in a way pigeon-holed. It was admitted that the asserted gap between the material and the immaterial world does exist; that the human mind can not conceive of the immaterial as acting upon the material; and that, therefore, the gap can not be conceived as bridged. But it was asserted that one could conceive of happenings in the immaterial world corresponding to, or parallel with, happenings in the material world; and that it was not at all necessary for the psychologist to explain *how* this was possible. It was only necessary to postulate that when something happened in one world, it was paralleled by something in the other world. It was not necessary to conceive that one happened because of the other. The claim was merely that when there was a happening in one world, there was a parallel happening in the other.

But even this statement of the case needed to be, and was qualified. Not every happening in the material world as represented by the nervous system, crowned by the brain, is accompanied (paralleled) by consciousness—by a happening in the mind. The stimulation must reach a certain portion of the nervous system—the cortex of the brain, and there must be a certain intensity of neural action in this cortex before the limen is passed and the mental life involved. But given this sufficient intensity of neural activity in the cortex, (in the material world), then the theory holds that there is parallel activity in the mind (the immaterial world).

But what about the power of the mind to break in upon, and to modify, the happenings in the material world of neural activity? What about the ability of the mind to execute its *purposes?* Parallelism is still a sufficient answer. One does not need to think of the change as caused by the mind. He only needs to think of the change as accompanying the given mental state.

The happenings in one world are conceived as so "set" or "tuned" with relation to the other world, that variation in one is accompanied by variation in the other. It may even be that one is a mathematical function of the other; but even in that case the concept is one of mere concomitant, not causal, variation. If one uses the language of interaction, and speaks of the mind breaking in, it is only because such language is more direct and saves the circumlocution which would otherwise be necessary.

In modern psychology, the so-called structuralists accept the parallelistic hypothesis, and so conceive the study of psychology in terms of the action of a nervous system paralleled under certain conditions by mind. They regard the organism as an adaptation system, and believe that mental changes accompany neural changes in the establishment of new adaptations for which the old mechanical systems are inadequate. They do not, however, make any attempt to tell how this occurs. They leave this question to philosophy, while they themselves study the nervous system in unexplained parallel relation to mind, and also try to arrive at the structure of mind through the aid of introspection checked up by the products of performance measured by laboratory instruments of precision.

This structural psychology was on its experimental side the child of the nineteenth century development of scientific physiology. But this trend toward scientific physiology and biology has also been responsible for the development of two other psychological points of view. The first of these is the functionalist view, and the second is the behaviorist view. Both regard the organism as an adaptation system; both tend to speak in biological or neurological terms. Their work puts a strong emphasis upon the nervous system, upon stimulus, and response, neurons and neuron patterns made by prenatal bonds between neurons, or by new bonds resulting from experience. Over these neuron patterns plays the neural force in response to stimuli, and behavior is the result.

The functionalist agrees with the structuralist in admitting the existence of mind, and in making free use of the terms mind, mental state, mental processes, etc.; but his view is perhaps less dualistic and more materialistic in that he looks upon mind as "the functioning of the brain". There is for him a mental correlate of the physical brain process, but that correlate is the mere process by means of which the brain performs its function. This process, being something different from the brain itself, gives mind a place, and relates the functionalist to the structuralist. But instead of being especially interested in the structure of mind, the functionalist is especially interested in the achievements of mind. He is interested in development, in organic evolution, in how the process has come to be what it is, and in what is its teleological (purposive) significance. So the structuralist and the functionalist are not necessarily different persons. Structuralism and functionalism are different points of view, focused upon different aspects of the total psychological field. They may belong at different times to the same person.

The behaviorist frankly puts mind out of consideration. He says that no one has proved or can prove that there is or is not a mind. Moreover, he says that for the study of psychology it doesn't make any difference. What is important in his opinion is behavior, and the possibility of the prediction of behavior, through the study of the nervous system, its original neuron patterns, and the formation of new patterns through experience. Hence he voluntarily relinquishes the study of mind in favor of the study of behavior explained by a nervous system operating by mechanical, biological law. Behavior counts; it is tangible. It can be objectively measured, is entirely free from metaphysical speculation, and is therefore the real subject matter for science.

There is no doubt that there is a place for this view of the behaviorist. There are certain psychological problems which can be attacked only on the basis of objective data, and this fact gives the behaviorist his field. But again it would seem that it is a part, only, of the total field, cut off by the limitations of a certain view which may be taken by any psychologist at any time. To regard it is an exclusive and all-embracing view, and so to give up the conception of mind as a directive agent, would seem to make the organism a mere automaton at the mercy of external influences. Certain psychologists are not willing to do this.

They feel that the automaton theory is outworn, and that man, at least to a certain extent, can exercise a power of initiative and thus influence his destiny through purposeful choice between responses. They feel that the prediction of behavior must be very incomplete without a study of this mind which has the power to vary behavior through deliberate choice. Thus they feel that to make psychology purely a study of organic behavior without raising the question of a directing mind is almost or quite to make it a study of biology or neurology. It is to them, in a sense, psychology with the psychology left out.

Thus it is clear that if one is to talk about intelligence as a psychological phenomenon, he must choose a definite point of view, especially with regard to the mooted mind or consciousness. This point of view, it goes without saying, need not be exclusively structural, functional, or behavioristic.

The view here taken will agree with the tendency of modern psychologists of all schools to drop the use of the word consciousness in favor of the word mind, or of the expression mental state, since consciousness sometimes carries with it a connotation more philosophical than scientific. There will, however, be disagreement with some psychologists in that (1) it will be assumed that mind does exist coextensive with a certain intensity of neural activity in the cortex, and (2) in that the parallelistic hypothesis will be accepted, but for convenience the language of interaction will be used. The specific function of mind will therefore be conceived as that of breaking in upon the mechanical causation of mechanical systems of response, thus making itself felt in changed behavior.

II. The modern theory of a unitary mind.

The assumption that mind exists, and at times exercises a directive power over behavior, has been accepted. Another step may be taken through the medium of a discussion of mental "faculties". The older metaphysical psychology, in its attempt to analyze the soul, naturally discriminated such faculties (functions) as sensation, perception, memory, imagination, etc. Even the most modern parallelistic hypothesis must be carefully safe-guarded or it falls into the same trap. The very attempt to differentiate between brain and mind is conducive to the difficulty. One thinks of neural activity in the cortex, and of a gradually increasing intensity in this activity. Perhaps it is a neural activity stimulated by light. When the intensity passes a certain limit the brain activity is paralleled by the simplest possible mental activity. This simplest possible mental state is given the name sensation. It becomes immediately natural to say that the mind has a faculty of registering sensations, and to discuss sensation as a mental faculty.

As more and more stimuli bent upon the end organs, raise the intensity of neural activity in the brain, and are paralleled by more and more sensations, immediate sensations merge with the associated past sensations into percepts. This gives the mind a faculty of perception. Then the power to bring back to mind the image of the thing itself is focused upon. Recognized images are responsible for a faculty of memory; vivified and reconstructed images, for a faculty of imagination; images used as symbols of meaning, for a faculty of ideation; and the relating of these images, for a faculty of thinking.

The difficulty with this scheme does not lie so much in the conception of the "faculties" as it does in the emphasis upon the independence of the faculties in action, and the correlated emphasis upon their ability to take training. The view was naturally evolved that through the training of any particular faculty a particular kind of power could be stored up and remain ready to be drawn upon for future use. Specific memory power, specific thinking power, etc., could thus be put in "cold storage" as it were, for a season when they might be needed.

Modern psychology, however, for sufficient reasons which do not need to be detailed here, has largely discarded the faculty idea, together with much of its attendant storage or "reservoir" theory. Some of the faculty names are preserved, because they express something which only the names can compass; but, nevertheless, mind, to the modern psychologist, is not cut up into separate parts, and does not act in separate parts. Mind acts as a whole, as a unit. When there is mental activity, it is activity of the whole mind—of a unitary mind. But this unitary mind can be focused in various directions. That is, one may speak of memory as a typical process of psychical activity. Mind as a whole, acts in this form. Recall is the main consideration, and is in the foreground; but all of the rest of the mind is in the background contributing its part. An analogy may be found in the one-celled organism, the amoeba, which can wrap a fold of its body about a minute particle of food, use the enclosing sack as a stomach, and digest the food. The focus is toward the sac; the form of activity is digestion; but all the amoeba body behind the sac is contributing its share to the process. The digestive function is a function; but not a function separate and independent in action. To carry the illustration a little further, the amoeba can also, in its attempts at locomotion, put forth a "foot" in any direction. Thus the body is focused anew in a new form of activity; but the foot is not separate and independent. It is, as it were, only a sign of the complete and unified action of the whole.

It is only in some such sense that terms such as sensation, memory, imagination, etc., are used in modern psychology. When neural activity of sufficient intensity occurs in the brain it is accompanied by sensation in the mind. But it is to be particularly remembered that this means just what it says. The sensation is *in* the mind so definitely as to be really but a name for a focus of the total mind. It is a sign of the complete and unified activity of this focused total mind. It is in such a sense, only, that use is made in this thesis of the term mental function, or of the specific names of specific functions.

CHAPTER II

CURRENT VIEWS OF ADAPTATION AND MIND IN RELATION TO INTELLIGENCE.

I. The confusion which these terms present.

Psychologists are agreed upon regarding the organism as an adaptation system. There is a difference of opinion about the rôle played by mind; but the assumption is here made that mind exists, and that it is, at times, a directive agent in adaptation. What about the relation of the terms adaptation and mind to the term intelligence? Current usage is very loose, and the result is confusion which can be cleared up only by first finding some common ground upon which all views meet, and then analyzing the difficulties beyond that point. The common ground is found in the fact that all usage agrees in placing the problems of intelligence within the problem of adaptation.

Further analysis, however, shows that there are writers who are willing to call all adaptation intelligent. They think of intelligence as belonging to the organic as opposed to the inorganic; and they think of the organic as able to adapt itself to environment, while the inorganic can not. Possibly some who passively accept this point of view have not even stopped to consider that the organic includes vegetable as well as animal organisms, and that vegetable organisms do make adaptations to environment. If this were called to their attention they would probably readily agree that in saying that the organic has intelligence, and the inorganic has not, they had meant to contrast only animal organisms with the inorganic.

There is a class of persons, however, who intentionally include both animal and vegetable organisms when they contrast the organic and the inorganic, and who are willing to call both animal and vegetable organisms intelligent, because of the power of adaptation which they possess. That is, some persons do intentionally claim that ability to make adaptations is identical with intelligence.

The source of the confusion lies in the failure to realize that adaptation is such a broad term that it must be split up into a number of different types of adaptation. Unless these types are discriminated in thought and terminology, those who discuss the subject are not speaking the same language because they are not giving the same connotation to the terms which they use. Hence the discrimination of adaptation types is the next problem.

II. Types of adaptation in relation to mind and intelligence.

A. ADAPTATION IN THE INORGANIC WORLD.

There is a use of the word which permits it to apply to the inorganic. Cliffs and other earth contours "are adapted to environment" when they yield to weathering by wind and water. Iron rails are adapted to environment when they expand or contract because of change of temperature. But these bodies are *adapted to* the environment; they do not adapt themselves. They remain passive, and are mechanically adjusted through the play of external agencies. Given approximately the same conditions, the variations which occur tend to be predetermined, and are therefore highly predictable. The body exhibits no spontaneity. There is no active, inner, selective factor which interferes to make the prediction of variation uncertain.

Now the idea of intelligence, no matter how else limited, has never failed to carry with it the assumption that, to some degree at least, the possessor is able to exercise a relatively non-predictable selective inner influence upon its own destiny. Hence there is no current reputable usage of the term intelligence which will permit its application to the inorganic. This is so self-evident that it would be a waste of words to say it, if it were not for the slip which sometimes identifies intelligence with adaptation. The inorganic does, in a sense, have adaptation. It does not have intelligence. Hence intelligence cannot be used as synonymous with adaptation without opening the door to confusion. Accordingly, in organizing the uses of the term adaptation, this thesis will distinguish between inorganic and organic adaptation, and will deny intelligence to the inorganic.

B. ADAPTATION IN THE ORGANIC WORLD.

1. Primary mechanical types.

a. Tropic adaptation.—There is a difference of opinion as to where to draw the line between tropism and real reflex or instinctive acts. The view here taken will be that which limits tropism to those organisms which lack a differentiated nervous system.* Such primitive organisms possess a generally diffused sensitiveness of the total protoplasmic mass. This sensitiveness promotes simple adaptation, but these adaptations have much of the same invariable (and therefore predictable) character as do the adaptations in the organic world. Water, light, and heat have been spoken of as having certain mechanical effects upon inorganic substances. They have also a total mechanical effect upon organic tissue, and through this effect may promote adaptations. But again, the body (even though it be organic) is *adapted to* the environment, it does not adapt itself. Again there is no active, inner, selective factor, no initiative, which interferes to make the prediction of variation uncertain. Hence in one sense there is no variation at all, and certainly no intelligence.

b. Reflex and instinctive adaptation.—In inorganic adaptations and in tropism there is assumed to be no intelligence, since it is conceived that in them the adjustments lack spontaneity, and are practically predictable. The body is at the mercy of its own material composition as acted upon by external agencies. But with instinctive adaptation it is different. Instinct utilizes a differentiated nervous system and succeeds in being less rigid, less predictable, and more selective, though the selection occurs in a mechanical manner.

Herrick says that theoretically the simplest organized nervous response is the reflex which depends upon merely the simplest receptor and effector organs, and one motor and one sensory neuron. He says further than some writers have been willing to classify such reflexes with the tropisms; but that others conceive the pure reflex as more theoretical than actual, and tend to move immediately from unorganized tropism to the instinctive response regarded as a group of reflexes. The latter view will here be taken.

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* Whether or not this includes plant life is a somewhat mooted question; but the essential facts of the present discussion will not be unfavorably affected if this question is dropped, and the matter discussed wholly from the point of view of the animal organism.

From one point of view the organized nervous response known as instinct, is entirely mechanical, prearranged. It is regarded as a selective or choosing agency, yet as selecting those stimuli, only, to which it is tuned to respond mechanically, and as always responding in the same way to the same stimuli. It is thought of as rejecting or ignoring the different; but when a stimulus comes which is similar to that to which it was meant to respond, and to which it has always responded, it is conceived as responding again in the same way. This view is only relatively true. The organism which responds instinctively through the aid of a nervous system is not so rigid and invariable in its adaptation to environment as are inorganic bodies, or even those creatures that depend upon tropisms. The nervous mechanism permits a certain limited initiative or self-adjustment in adaptation, although one must hasten to say that self-adjustment is not here used in the sense of purposive or intentional adjustment. There is merely a mechanical selection, based upon limited possibilities residing in an originally organized mechanism. Birds of the same species build similar nests; but no two of them build nests exactly alike in all particulars. No one conceives that the bird intentionally selects the changes. The power of selection lies in the elasticity of the mechanism, and this elasticity is limited. Yet to this limited degree the creature of instinct does influence its destiny through the exercise of an active, inner, selective factor; and to this degree its variation is non-predictable. The organism in a measure adapts itself, and is not *adapted to* its environment. This has led many to wish to use the word intelligence to apply to these mechanical variations in instinctive behavior. There is a limited sense in which the word might be so used. A problem has really been solved through focus upon a situation, plus action which is based upon selected (chosen) similarities. But the control in the whole process is mechanical and not intentional; and if the term intelligence is applied, it needs to be qualified by emphasis upon the mechanical control. This type of mechanically controlled intelligence, this plasticity in original instinctive response, is unlearned, and in that sense non-productive. Only original neural patterns are called upon; but there is a limited mechanically controlled choice between persistent originally arranged systems woven between the neurons which are the units of the nervous system.

c. Modified instinctive adaptation.—But original instinctive response does, at times, through the mere conflict of the original mechanical systems, cease to be the only resource of an organism. As an illustration it may be noted that an organism may have an original system of response which makes it tend to avoid pain through withdrawing movements. It may have another original system which leads to approaching movements in the presence of a bright object, e.g., a hot stove. The mere mechanical conflict of these two systems may lead to the suppression of one of them and to the supremacy of the other.

The characteristics of this type of adaptation are very similar to those of original instinctive adaptation. The choice is on the basis of similarities; and a problem is solved, although there is no formation of new neuron patterns. The variation is also less predictable than in tropisms or in inorganic adaptation. The organism is not merely *adapted to* environment. To a degree it has initiative and it adapts itself. There is an inner, active, selective agency at work, but the control exercised by this agency upon the destiny of the creature is mechanical and not intentional. If there is intelligence, it is still mechanically controlled intelligence. Learning may be said to have taken place, because the variation, unlike that in original instinctive response, is not merely a mechanical choice between persistent possibilities, but is the result of a permanent suppression of one original tendency in favor of another original tendency. Thus the act is productive mechanically controlled intelligence.

d. Associative adaptation.—In the types of adaptation thus far noted, no new neuron systems are formed. There is often, however, an excess neural discharge. This comes especially in times of emotional excitement. Many random movements are then made as the excess discharge forces itself through new channels. If discharge through a new channel brings satisfaction, the new movement is associated with it, and this movement comes more certainly the next time. Thus gradually new neuron patterns are formed and behavior is varied; problems are solved; learning takes place. This learning utilizes the neural-switchboard, and shoots upward to a sensory-motor level above the level of the mere reflex arc; but it does not go high enough to get into the level of intentional control. It is at first a chance choice due to mechanical spontaneity, and it is continued as a mere mechanical association with a sense of well-being.

Even rote learning of a song or other school exercise may occur in the way just described; and many common manners and customs also have the same origin. The problem is not intentionally or logically attacked; but repetition, plus a favorable affection, blocks out the new pathways, and establishes the new neuron bonds or patterns. It is only trial and error learning, or incidental learning. Yet the creature is not merely *adapted to* its environment. It adapts itself, although in a mechanical manner. Therefore the word intelligence is applicable if the act is realized to be an example of mechanically controlled intelligence. Mind, if present at all, is still not a directive agent. In popular terms, a mechanical habit has been mechanically formed. This type of adaptation is the least predictable type thus for discussed.

2. Purposive Type.

a. Intentional adaptation.—There have been discussed two types of unintelligent adaptation: (a) the inorganic adaptation; and (b) tropism. There have also been discussed three types of limited-intelligent adaptation: (a) original instinctive adaptation; (b) modified instinctive adaptation; and (c) associative adaptation. But there comes a time in the life of an organism when none of these types of adaptation can meet the new situation which is presented. When such a time appears, the organism suffers, or even perishes, unless it is an organism possessing a mind which can break in to solve its problem by influencing the nervous currents to the formation of new neuron patterns necessary to a new adjustment intentionally chosen out of the possibilities which the situation presents.

The theory involved in the interference of mind in the formation of new systems of response has already been briefly outlined. It is that there must be involved a certain grade of refinement of the nervous structure found only in the cortex, and a certain intensity of the neural activity in the cortex, before the limen is passed and the mental life is able to function. That is to say, that mind is coextensive with (1) a certain intensity of neural activity, and (2) in certain structures. One of these conditions alone is not enough. Mere intensity in the lower structures, or mere activity in the cortex, must give place to *a certain intensity in the cortex* before the limen is passed. (But it is conceivable that cortical activity which is not intense enough to pass the limen may have an indirect mechanical influence upon mind, through its influence upon the cortex.)

Below the limen, therefore, is mechanically controlled adaptation. The function of this intentional activity of mind is to meet those emergencies in which the mechanical systems break down. Asuming that mind is able to do this, a certain analysis may be made of the method. This analysis cannot fail to be rather rigid and dogmatic, but it is not intended to be inflexible. All discussion of types must attempt to make the type specific as if it stood out sharply by itself, even though in reality it grades imperceptibly into adjacent types. Purposive adaptation does not always appear unadulterated; but, theoretically, in its pure form, it presents the following named elements, each one of which is to be understood as intentionally carried out:

1. Focus upon possibilities; in other words, concentration, or attention.

2. Pause; the mechanical currents must be temporarily inhibited.

3. Selective activity; significant elements in present and past situations must be abstracted and held by themselves.
4. Relating of the selected elements.*
5. Action upon the relationships discovered.

When the literature is examined in the next section it will be found that the modern tendency is to reserve the term intellignce for this type of adjustment, or adaptation, which solves problems by the steps just enumerated. However, if one has decided to use the expression "mechanically controlled intelligence" for unintentional adjustments, he can use a qualifying term for these directed adaptations, and call them "intentionally controlled intelligence." They may also be called productive intentionally controlled intelligence, since they really produce new connections, and new behavior.

This same type of adaptation has other names such as intentional learning and thinking. It represents the height of power of the active, inner, selective factor which produces non-predictable variation. It is the means by which the organism escapes being merely *adapted to* its environment, and succeeds in *adapting itself* to the environment, or in adapting the environment to itself. It is the open door to controlled progress.

Throughout this thesis therefore there will be made an attempt to separate the various aspects of mechanically controlled adaptation from intentionally controlled adaptation. The following list of terms wll help to insure this separation:

Inorganic adaptation (unintelligent).
Organic tropic adaptation (unintelligent).
Non-productive mechanically controlled intelligence.
  a. Original instinctive adaptation.
Productive mechanically controlled intelligence.
  a. Modified instinctive adaptation.
  b. Associative adaptation.
Productive intentionally controlled intelligence.

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*What kinds of relationships is the mind able to conceive? Cause and effect, time, space, genus-species, part-whole, likeness and difference; how many are there to be found? Can all be reduced to one; viz., similarity? Time relationships are gathered because they are similar; so with place relationships, etc. Then ability to relate becomes just that ability which is able to recognize in present experience an element similar to one belonging to a past experience.

3. Secondary mechanical type.

a. Reproductive (habitual) adaptation.—It is well known that an act which once required the immediate, purposive supervision of mind, may, through repetition and other circumstances, fall back to be performed by new-formed mechanical-neural systems. Mind is thus released for new ventures in new fields. The act that is thus relegated to mechanical systems is no longer an intelligent act in the sense of intentionally controlled intelligence. It is intentionally controlled intelligence only in so far as it has not been so relegated. The process of relegation consists in a gradual fading away, out of the focus of mind into the fringe. The act thus becomes more and more predictable, and finally drops entirely below the limen into the mechanical, the unintelligent, or the mechanical-intelligent, if one wishes to use this term. It becomes habit, and, for the purposes of this discussion, belongs with the mechanical adaptations. In this connection it can, through mechanical conflict with other mechanical systems, bring about mechanical learning, just as in the already discussed conflict of two original mechanical systems.

But this act which was once intentionally controlled, and has now become mechanical, has not at all the same significance as the original mechanical. It stands not only for mechanism, but it stands also as evidence of a former exercise of intentionally controlled intelligence. It can be brought back into the intentional; and it could not have been performed at all without the original exercise of the intentional. It is, therefore, secondary evidence of intentionally controlled intelligence, since in all probability, the formerly exercised power still persists in the organism. And this secondary evidence often has an importance nearly or quite equal to the primary evidence afforded by a new adaptation itself.

This secondary evidence of intentionally controlled intelligence, this giving back of something learned at a previous time, may be called pedagogical intelligence, or reproductive intelligence. It is the diary of the intentionally controlled intelligence.

III. *The definition of intelligence.*

It has been customary among students of intelligence to say that it is not known what intelligence is. The view taken here is that what has been meant is that types of intelligence have not been discriminated, or that the fundamental nature of intelligence has not been known; but that it has been known what intelligence is, and that the preceding discussion has shown what it is. To accomplish this end did not require experimentation, but only an examination of the usage of the word. For any term has content only through usage, and that usage may give it any content whatever. It has been shown that the usage of the word intelligence has been rather definite, except that types of intelligence have been allowed to overlap. It follows that the definition of intelligence should be broad enough to include all types admitted by usage, and that supplementary definitions of the individual types should be given. The broad and all-inclusive definition may be worded as follows:

AN ORGANISM IS INTELLIGENT WHEN IT POSSESSES THE ABILITY TO INFLUENCE ITS DESTINY THROUGH THE UTILIZATION OF AN INNER, ACTIVE, NON-PREDICTABLE, SELECTIVE FACTOR WHICH CHOOSES ON THE BASIS OF SIMILARITY.

This definition, since it includes mechanical choice, does allow intelligence to practically all animal organisms; and that is just what some writers of importance wish to do. If, however, one wishes to distinguish intentionally controlled intelligence as a pivotal type (and this is the only type which many writers recognize) he must make a more qualified definition as follows:

AN ORGANISM HAS INTENTIONALLY CONTROLLED INTELLIGENCE WHEN IT POSSESSES THE ABILITY TO INFLUENCE ITS DESTINY THROUGH THE INTENTIONAL UTILIZATION OF AN INNER, ACTIVE, NON-PREDICTABLE, SELECTIVE FACTOR TO EFFECT A SPECIFIC PURPOSE THROUGH INTENTIONAL CHOICE BASED UPON SIMILARITIES.

IV. *Summary of Chapter II.*

1. It is agreed that the problem of intelligence is within the problem of adaptation.

2. But adaptation is in no sense intelligent until a body utilizes an inner, active, non-predictable, selective factor to influence its destiny. Hence inorganic adaptations, and even organic tropisms, are not intelligent.

3. Organized response may be mechanically controlled as in (a) original instinctive adaptation; (b) modified instinctive adaptation; (c) associative adaptation. If these are regarded as intelligent at all, it can only be in a limited sense, and they should be known as mechanically controlled intelligence.

4. Organized response may be intentionally controlled. This is the type of adaptation generally recognized as intelligent. It is intentionally controlled intelligence in contrast to the mechanical control. Its variation is relatively non-predictable.

5. Intentionally controlled intelligence may lapse into mechanism, and become a secondary mechanical type, valuable as the diary of the intentionally controlled intelligence.

6. Intelligence may, therefore, be defined as in Section III of this chapter.

CHAPTER III

TYPES OF STUDIES IN THE QUANTITATIVE DETERMINATION OF INTELLIGENCE.

The lack of discrimination between the types of adaptation discussed in the last chapter, has naturally encouraged looseness in discrimination between types of experimental studies of intelligence. There is also an added difficulty arising from the tendency to claim that one has measured intelligence when, in reality, he has not done so at all, but has only measured some trait correlated with intelligence. These points will be covered very briefly in the present chapter, the latter being taken up first.

I. Measures, not of intelligence, but of factors found to be correlated with intelligence.

A. CORRELATION OF PHYSICAL TRAITS WITH INTELLIGENCE.

If it is found that intelligence usually goes with a head of a certain width or length, then the measuring of the heads of a group of people may give an insight into the probable amount of intelligence in the group. But, in spite of this, it cannot then be truthfully said that the intelligence has been measured. The presence of intelligence has only been inferred as a result of the head measurements. In one sense the result is the same no matter how it is stated; but, if, in such a case, intelligence is really thought of as measured, false ideas as to the true nature of intelligence are fostered.

Good examples of the measurement of physical traits correlated with intelligence are found in the early part of the first volume of Whipple's "Manual of Mental and Physical Tests". First are certain anthropometric measures, such as have often been used in the identification of criminals, and in the relation of growth to disease, etc. Definite degrees of these traits have also been found usually to be associated with intelligence, and the presence of the given degree of the trait therefore leads to the inference of the presence of intelligence. Examples of such measurements are those of height (standing and sitting), weight, diameter of skull, girth of skull, etc. In like manner are utilized measures of vital capacity, strength of grip, physical fatigue, quickness of movement, accuracy of movement, and involuntary movement. The same thing also applies to measures of sensory defect due to physical conditions. Deafness, long- and short-sightedness, color-blindness, control of eye muscles, and such may be cited as examples. Any one of these traits may be found in varying degrees of correlation with intelligence or lack of intelligence. To measure the trait may lead to results which justify the assumption that intelligence will be found along with it; but it does not determine the degree of the intelligence either for the group or for the individual.

B. CORRELATION OF MENTAL TRAITS WITH INTELLIGENCE.

Studies which merely show that amount of perception, memory, etc., is correlated with intelligence, are not measures of intelligence itself. Again it will prevent confusion concerning the true nature of intelligence if such studies can be set off by themselves as the studies of physical traits have been.

It is common to think of a person of good perceptive power, good memory power, etc., as an intelligent person. But it has been repeatedly proved that even the feebleminded may possess these powers. The difficulty lies in the identification of (1) the admitted possession of the trait, with (2) the ability to manipulate the trait in the service of non-predictable variation. Percepts and memories are bundles of relationships. A person is not born with them. Hence their building up may be called variation; but, in the main it is a predictable variation. There is a natural course of events on the basis of which one could, if he knew all the circumstances, predict the formation of percepts, memories, etc., just as he could under similar circumstance predict the crystallization of steel under shock. This predictable variation, the main objective of the extreme "Behaviorist", is not intelligence. Intelligence is not present until mental elements (functions) are, either mechanically or intentionally, brought into relationships which result in non-predictable variation. The real measure of intelligence measures spontaneity or initiative. It is true that in the formation of percepts, etc., there may have been present in a particular case some of this initiative (mechanical or intentional); but much of the process is likely to have been of the predictable kind; and one does not with certainty get at the spontaneity, therefore, through the measure of the function. The functions are prerequisite to intelligence, since the initiative can not come if the functions are lacking. But the functions may by measurement be found in varying amounts, and yet intelligence, non-predictable variation, be lacking, or at least unproved because it is obscured by the excess of predictable variation with which it is associated. If one wishes a reliable measure of intelligence he tests not the amount of the function, but the amount of initiative which the creature can produce through the discovery and utilization of relationships between the functions.

Examples of quantitative measures of sensation are the common tests of visual acuity (Whipple, Test 14), and auditory acuity (Whipple, Test 18), etc.; of perception, are the common tachistoscopic tests of range of visual attention (Whipple, Test 24), and visual apprehension (Whipple, Test 25), etc.; of rote memory, (Whipple, Test 38), etc. One may find these and other mental abilities correlated with intelligence; but the measurement of them is not a measurement of intelligence itself.

II. Real measures of intelligence.

A. MEASURES OF MECHANICALLY CONTROLLED INTELLIGENCE.

1. Original types (unlearned).

Here belong all those studies of endowment which aim to achieve a knowledge of the amount of a creature's orginal and unlearned ability to solve problems, e.g., non-predictable variations in the nest building of birds, in the migration of species, in the food habits of wild mice, etc. The variations here studied, however, are those which come within an original range of native ability, and not those which supplant or augment original abilities. They are discussed in the former chapter under the head of original instinctive adaptation.

2. Learned types.

These are the ones previously discussed as modified instinctive adaptations and associative adaptations. They represent real non-predictable variation, but it is still of the mechanically controlled type. The field has been much exploited, and illustrations are numerous and well-known. Typical ones are the animal intelligence experiments of Lloyd Morgan, Thorndike, Yerkes, and Watson. All experiments in unintentional, associative, learning, or incidental learning in either human beings or animals belong here.

It may be said in passing that if the distinction between mechanically controlled intelligence and intentionally controlled intelligence were kept well in mind, much light would be thrown upon the dispute as to whether or not animals are intelligent. Animals do solve problems, but the consensus of opinion is that they solve them either through the small latitude of non-predictable variation allowed by instinct, or they solve them through conflict of instincts or through association. They do not solve them through working out of a deliberately chosen purpose based upon relationships intentionally sought between mental elements. From this point of view, animals have mechanically controlled intelligence, but not intentionally controlled intelligence.

B. MEASURES OF INTENTIONALLY CONTROLLED INTELLIGENCE.

Illustrations of intentionally controlled intelligence must be those featuring immediate and intentional problem solving. There can be included no primarily mechanical associative or instinctive processes. A new situation presents itself and is purposively attacked and solved through the discovery of new relationships. Cats get out of cages through mechanically controlled intelligence. A normal human being in the same situation uses intentionally controlled intelligence, and attempts purposively to apply past experience to the present situation, find the similarities between the past and present, and so find the way out.

Some of the best developed modern single measure of intentionally controlled intelligence are certain tests of intentional sensory discrimination, certain picture-completion and other performance tests, the synonym-antonym test, the analogies, etc. As has already been said, this type of intentionally controlled adaptation is the only type that many writers are now willing to call intelligence; but it can do no harm to call mechanical phases of adaptation mechanically controlled intelligence, if mechanically controlled intelligence is definitely discriminated as a type.

C. MEASURES OF REPRODUCTIVE INTELLIGENCE.

The human mind is so constituted that after it has solved a problem once or several times, the solution becomes mechanical. At first there is required active attention and intention; later attention becomes what has been called secondary passive, intention drops out, and the act performs itself. It becomes reproductive intelligence because it reproduces mechanically the acts of the intentionally controlled intelligence. Many persons have not been willing to call pedagogical tests intelligence tests. It is true that a test in geography or history may require merely the mechanical reproduction of something previously learned; but the person may, and probably did originally, pick up much of the knowledge intentionally. And psychologists are more and more coming to believe that measures which determine how much a person has intentionally achieved through a term of years are often more significant than those measures which only find out his present achievement through a period of an hour more or less. So psychologists are not nearly so much afraid as they used to be of the pedagogical measurement regarded as an intelligence measurement. There is, however, a fundamental difficulty in the fact that one seldom is able to tell exactly how much of the reproduced material was originally acquired mechanically, and how much was acquired intentionally. Hence one cannot tell how much credit to assign to mechanically controlled intelligence, and how much to assign to intentionally controlled intelligence.

Illustrations of pedagogical (reproductive intelligence) measures are those of arithmetical fundamentals such as the Courtis, series A and B; arithmetical reasoning, such as the Stone Reasoning Test; reading scales, such as the Kansas standardized reading tests; handwriting scales, such as the Thorndike scale and the Ayres scale; and the composition scales, such as the Hillegas scale, the Harvard-Newton scale, and the Willing scale. In fact one now finds such scales for practically every subject of instruction.

CHAPTER IV

THE FUNDAMENTAL NATURE OF INTENTIONAL ADAPTATION.

I. The "common factor" in intelligence.

Certain types of adaptation have been discriminated in previous chapters. Evolutionary tendencies in modern thought would naturally lead one to suspect a development from one type to another, but it is not the intention to pursue that idea at this time. It is now necessary, however, to call attention to the fact that the discriminations heretofore made between the non-intelligent, the mechanical-intelligent, and the intentional (purposive)-intelligent, are all based upon the conception of a "common factor" in intelligence. That common factor has several names such as seeing relations, thinking, judging, profiting by experience, etc.; and its exercise results in initiative, spontaneity, or non-predictable variation. Binet's own statement of this common factor is very significant, although he does not use it to make the distinctions herein urged. He says:* "It seems to us that in intelligence there is a fundamental faculty, the alteration or the lack of which is of the utmost importance for practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances. To judge well, to comprehend well, to reason well, these are the essential activities of intelligence. A person may be a moron or an imbecile if he is lacking in judgment; but with good judgment he can never be either." Hence it is here conceived that where the capacity for judgment and non-predictable variation is lacking, intelligence is lacking. It has also been shown that above the unintelligent, there is a level of mechanically controlled intelligence (original and acquired), marked by mechanical judgment; and above that, a level of intentionally controlled intelligence, marked by purposive judgment. It may be pointed out that the discrimination between the mechanical-intelligence and the purposive-intelligence is a discrimination based not upon quantity of the common factor, but upon quality of that factor. Judgment, initiative, spontaneity, of a mechanical quality marks mechanically controlled initiative. Judgment, initiative, spontaneity of a purposive quality marks intentionally controlled intelligence. The remainder of the thesis will be occupied with attempts to determine the fundamental nature of the intentional or purposive type of intelligence, together with a consideration of the implications arising from the conclusions reached.

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*The Development of Intelligence in Children, Vineland Laboratory, 1916; p. 42.

There are, of course, all degrees of gradation between a completely mechanical adaptation, and one which is completely intentional. It is even true that very many adaptations which on the surface are intentional, are at bottom a mixture of both types. But since the crucial importance of the intentional type as the key to directed human progress is acknowledged, and since it does, at times at least, occur approximately according to the rather schematic plan already outlined, it can do no harm to continue the discussion from that standpoint.

In the type of adaptation under consideration, mind is conceived to be an active factor. Through it a positive purpose of an individual is carried to its conclusion. It is a method of active solution of problems, through focus upon the possibilities of the situation, pause, selection of significant elements, and the recognition of relationships between the selected elements. But what are the elements between which relationships are found? They may be perceived material things, images of things, or symbols of things. With relation to any pair of such elements, thinking is possible. Each one of the pair is, as it were, held out by itself, and compared with the other. Then decision is made as to whether or not they belong together. But it is at first easier to do this when the objects can be obtained and handled (perceived) than it is to deal with images of the objects. And it is easier to deal with the images than it is to deal with symbols of the images or of the things themselves. Long before there was any organized science of psychology the intuitive psychology of the people made its own statement of this fact by saying that it is easier to solve a problem in the concrete than in the abstract. It is the idea involved in this natural and fundamental usage which is to be here appealed to in attempting to solve the fundamental nature of intentionally controlled intelligence, just as usage was appealed to in former chapters to establish the definition of intelligence.

The relationship under consideration is apparent even in different degrees of development of the human race. The savage does not deal with abstractions so easily as with the concrete things that come to his hands. The average intelligent member of modern civilization who easily solves ordinary problems in arithmetic, finds himself baffled in the presence of the same problems put into generalized terms. Inevitably when thinking of these things one leans toward a genetic theory of development even within intentionally controlled intelligence itself. For although the mind acts as a unit in intentional control, it is nevertheless easy to believe that early in the evolution of this power, although all possibilities of mental action were potentially present, the unit-activity (function) of perception was predominant in problem solving. On this theory, progress has consisted in the gradual supplementing of the perceptual activity by other unit-activities involving images and symbols.

Moreover, it seems probable that this same progression roughly characterizes the life of the individual. It is probable that in his acts of intentionally controlled intelligence he deals easiest and oftenest with things, then with images of things, then with symbols. Upon this theory, feeblemindedness, which is now everywhere recognized as retardation in mental development, is a retardation in passing from the preponderance of one of these forms of activity to another. Thus the common factor, judgment, again asserts its power by determining levels even within intentionally controlled intelligence itself; and the person of low purposive intelligence is seen to be the one arrested primarily upon the level of concrete relationships, which his more fortunate mates pass on to the more ready manipulation of the image and the symbol. But again it is quality, or type, of judgment, and not quantity, which determines the levels; although one is, of course, immediately interested in the quantity of the given quality which can be delivered.

But the conception of intelligence as arranged in levels, which levels are differentiated in terms of mental functions, or mental unit-activities, is not identical with that theory of intelligence which attempts to measure intelligence through mere quantitative measurement of each function. Binet, and many others, have shown very clearly that a person may have good memory, for example, and yet be unintelligent. Binet says:* "Just at the present time we are observing a backward girl who is developing before our astonished eyes a memory very much greater than our own. We measured that memory and we are not deceived concerning it. Nevertheless that girl presents a most beautifully classic type of imbecility." The point is that the memory is there, but that *the power to make non-predictable relationships between memories* is lacking. Thus, as shown in Chapter III, the quantitative measurement of the function is quite different from the measurement of power to solve problems in terms of the function. Yet the functions do determine the levels upon which the problem-saving may occur. To handle as many levels as there are functions, however (sensation, perception, imagination, etc.), attempts a minute classification which it is relatively impossible to achieve, because of the overlapping of the modes of activity. It is safer to condense the levels to three: (1) that of sensation and perception, (2) that of the image, and (3) that of the idea regarded as a symbol plus a meaning. Intentional adaptation (purposive problem-solving, thinking, learning) may take place through the relating of percepts, or of images, or of ideas.

Evidences which point toward the truth of this hypothesis are numerous in popular experience, and in the existing literature of intelligence. In fact the evidences are so clear that it is surprising that they have not hitherto been gathered up and applied to the better understanding of the nature of intelligence, and to methods of measurement of intelligence. The steam has been lifting the lid of the kettle for a long time, but the significance of the fact has remained obscure.

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* The Development of Intelligence in Children, Vineland Laboratory, 1916; p. 43.

II. Existing evidences that purposive intelligence is conditioned by levels based upon an analysis of mind.

1. The generally accepted idea that the abstract is "harder than the concrete".

Since concrete and abstract are only popular terms for the more technical psychological concepts of sensation, perception, memory, ideation, etc., the popular concept of degrees of intelligence is, therefore, seen to be in terms of a natural analysis of mind, stated as types of activity.

2. The popular, but contradictory, conception that pupils considered dull because they fail in abstract subjects, prove their intelligence by success in concrete subjects.

Over and over again, the child who cannot learn arithmetic, history, geography, etc., is assigned to manual training or other subjects in which concrete situations predominate, and succeeds in the new field. To say, however, that because of this success he proves his intelligence, is to go contrary to the belief that abstract subjects are harder than concrete ones. Even to say that one who fails in abstract subjects and succeeds in concrete ones has a different kind of intelligence, does not meet the point. He has also a different degree of intelligence. The progress of humanity, all the higher life of man, depends upon the control of the abstract. A civilization based mainly upon the concrete would be a civilization set back indefinitely. A person who lives mainly in the concrete is a person who has not the intelligence to enter fully into the life of the race to which he belongs. He has some intelligence, but it is only a limited intelligence. He lacks certain levels of ability which are possessed by the mind more capable of abstraction.

3. Courses of study in institutions for the feeble-minded.

The predominating type of material is perceptual. Manual training, and all of these subjects of instruction which tend to feature predominantly the concrete, form the bulk of the curriculum. Only the most elementary abstract work is attempted. (Thought work used consistently as pre-requisite to construction, could, and often does, raise the level of intelligence required by manual training, and make it a valuable study for modern schools. Then, however, the feeble-minded do not succeed in it so well.)

4. Clinical descriptions of typical feeble-minded persons.

These nearly always show the tendency to arrest in the territory of the concrete More than that they show that in concrete work such cases are, sometimes and even often, the equals or even the superiors of more intelligent subjects. That this is so, constitutes one of the most significant facts confirming the theory of intelligence herein advocated, since it shows that on the perception (concrete) level, high and low intelligence are much closer together than they are on the more abstract levels. Below is Doll's account of a typical feeble-minded case. The reader is asked to note how the concrete is emphasized in this case, both in the results of the mental tests, and in the subject's ability in manual and industrial work.

Doll: Clincal Studies in Feeblemindedness, Badger, 1917, pp. 81-89.

"Donald, born 4/14/95, was first examined 3/5/10 at the age of 14.9. By Goddard's 1910 revision of the B-S scale his mental age was 9.6 years. He passed all the tests at years VI and VII, failed memories at VIII and at IX, passed months and money at X, and absurdities at XI. Absolute retardation amounted to 5.3 years, relative retardation, 36 per cent. I. Q. was 64, and gave rise to a diagnosis of feeblemindedness, and a classification of middle grade moron. . . . Only extended and well directed conversation makes one conscious of his mental deficiency; then, a poverty of ideas, a lack of originality, limited information, and vague comprehension of abstract relations are apparent. But these are subjective impressions of which most visitors who interview him seldom become aware. They stand out more definitely and clearly under observation in standard situations. . . . A formal pedagogical examination was not made, but school reports are now available. These show that he attended an orphan asylum school for two years, but made no appreciable progress. Furthermore, in spite of the exceptional advantages offered by the school department of The Training School, with its intensive and extensive individual teaching, he has never been reported as being able to do better than poor first-grade academic work. In music, and in manual and industrial work, he came to be one of the ablest of all the pupils. In particular he did well as a farm hand and learned to handle machinery, and to work with comparatively little supervision. He played well on the bass horn, both band and solo work, and although he was somewhat careless he had the reputation of being, under supervision, 'the finest industrial worker in the school'. . . . Donald was examined by the writer 5/27/15, using Goddard's 1911 revision of the B-S scale. The result showed a mental age of 9.6, which was identical with the first and four succeeding examinations by different examiners. In these repeated tests he showed some losses and some compensating gains over the earlier tests but the gross results have always been identical. He passed all tests up to year IX. At X he failed to make change, saying that three cents from twenty gives sixteen, seven from twenty-five cents gives seventeen, and six from twenty gives eighteen, with the actual money before him. As an independent member of society he would be dependent upon the honesty of merchants or the kindly financial assistance of friends. At year X he exhibited only hazy knowledge of the pieces of money above one dollar (although he had had ample opportunity to know money values), failed in the abstract comprehension tests, and in constructing a sentence. At year 11 he succeeded with the rhymes, but missed all the other tests of that year. At twelve he passed only the suggestion test, and that in a manner to merit discount on the basis of previous experience and memory. His failure in these tests could not be said to be due to lack of scholastic or other training, for he had been pressed to learn all that his mental ability enabled him to assimilate. . . . Thus all experience and observation with Donald confirm the diagnosis made in 1910. At the end of five years of intensive training in all fields of learning his mental capacity is the same as at the first examination. This case is typical of the milder forms of high-grade defect frequently met with in institutional experience."

5. Evidence drawn from the construction and the application of certain intelligence tests.

The evidence appealed to here will be that which shows that the power of the so-called "performance" material to differentiate mental age tends to decrease above the age of about eight years, and to reach its limit about the age of twelve years. By "performance" material is meant those tests which utilize concrete material and appeal mainly to sensation and perception. Form-boards, picture puzzles, etc., are typical examples, although the variation in the field is practically unlimited.

A. ILLUSTRATION FROM THE BINET TESTS.*

Most of the tests in the early years are either perceptual as in III(1), III(2), III(3), IV(1), IV(2), etc., or they are reproductive of something which has been picked up through the experience of much repetition and reproduced from memory. Examples of the latter are III(4), III(5), etc. But it is to be noted that such material decreases upward through the years, more abstract material is added, and more immediate solution of new problems is called for. By the age of ten the concrete material is practically gone except for X(3) (designs), and X(Al.3) (Healy-Fernald Puzzle A); and the problem with the designs draws heavily upon image states as well as upon perceptual states. It is true that in year XII one finds the Ball and Field problem which might be classed as a performance test; but the scoring in this year requires "superior plan", which means that a thoroughly logical and complete abstract conception must precede the performance.

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*Terman, The Measurement of Intelligence, Houghton-Mifflin Co., 1916.

B. ILLUSTRATION FROM THE DE SANCTIS TESTS.†

These tests constitute a graded series. Assuming that the correct materials are present, a rough notion of the procedure can be obtained from the following:

1. Give me a ball.
2. Which is the ball you gave me?
3. Do you see this block of wood? Pick out all the blocks like this from the pile on the table.
4. Do you see this block? (a cube). Point out a figure on the form chart that looks like it. Take this pencil (or pointer) and point out all the squares on the chart as fast as possible without missing any, taking the figures line by line.
5. Here are some more blocks like those you have pointed out on the chart. Look at them carefully and tell me (a) how many there are, (b) which is the largest, (c) which is the farthest away from you?
6. Do large objects weigh more or less than small objects? Why does a small object sometimes weigh more than a large one? Do distant objects appear larger or smaller than near objects? Do they only seem smaller or are they really smaller?

Determination of the degree of mental deficiency in accordance with the tests.

1. If the subject does not pass the second test the mental deficiency may be considered of a high degree.
2. If the subject cannot go beyond the fourth test, or if he makes many mistakes or is very uncertain in the fifth, the mental deficiency may be considered of a medium grade.
3. If the subject succeeds in five tests but finds the sixth difficult, the mental deficiency may be considered of a slight amount.
4. Finally, if the sixth test is completed without mistakes, the subject may be said to present no mental deficiency.

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† De Sanctis, Mental Development, etc., Journal of Educational Psychology, 2, 1911.

Note (1) how the work in this series begins on the perceptual level in very uncomplicated form; (2) how the perceptual is gradually complicated; and (3) how the perceptual gradually gives way to the symbolic; and (4) how finally, in the directions for determining the degree of mental deficiency, the decision rests absolutely upon the ability to climb this ladder from the perceptual to the symbolic.

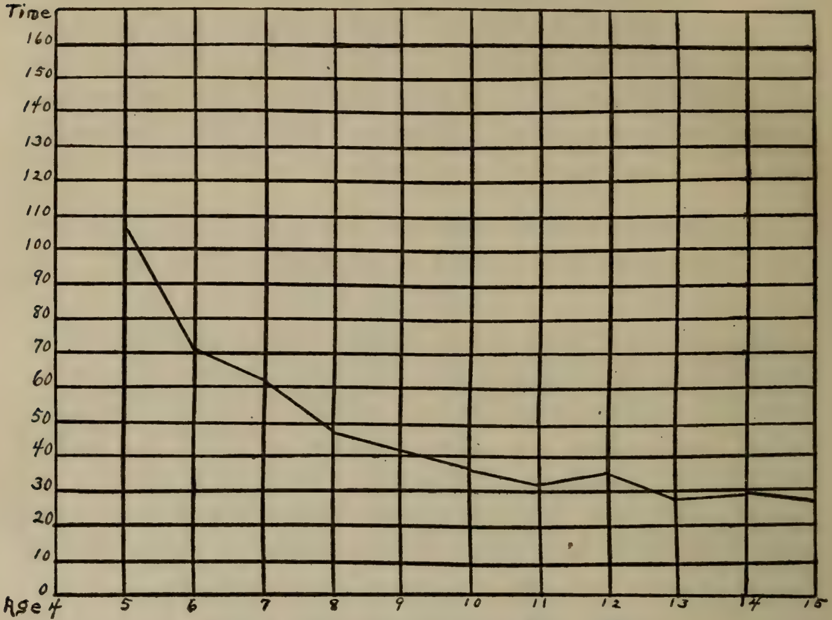
C. ILLUSTRATIONS FROM MATERIAL UTILIZED BY PINTNER AND PATTERSON IN "A SCALE OF PERFORMANCE TESTS" (APPLETON '11).

Examination of these graphs makes it clear at once that between five or six years, and nine and ten years, mental ages are fairly well, and in many cases very well, discriminated; but about ten the curves show a growing tendency to flatten out and to continue upon a plateau. By the age of twelve this tendency has gained such power that the graphs show little differentiation above that point, and where differentiation is shown by the graphs in years thirteen or fourteen, the experience of at least some of the users of the tests has been that results are not likely to be very reliable in those areas.

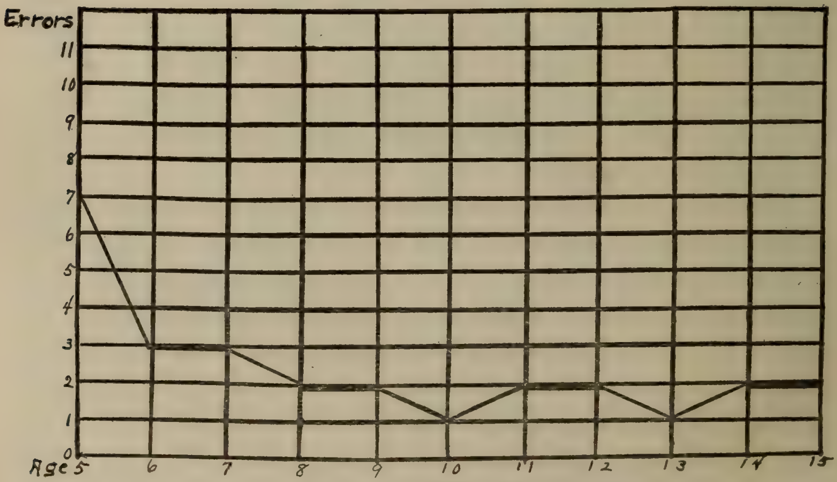
There is at least one exception, among the graphs, to the conclusion just reached. The reference is to the Knox Cube Test (Graph 27). This test shows better differentiation which may be referred to the fact that the discerning and holding in mind for repetition, of the increasingly complex series of responses, utilizes more than do the other tests powers which are superior to mere sensation or perception.

When one looks at the amazingly uniform tendency of performance tests to reach the limit of their differentiating power at a point roughly shown in the graphs, one must feel that it is probably more than a coincidence that a mental age of ten or twelve for adults has usually been chosen by intelligence experts as the dividing line between normality and feeblemindedness. It seems probable that performance test standarizations have, perhaps unwittingly, established the approximate point where abstraction must gain the ascendency, or subnormality become apparent.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

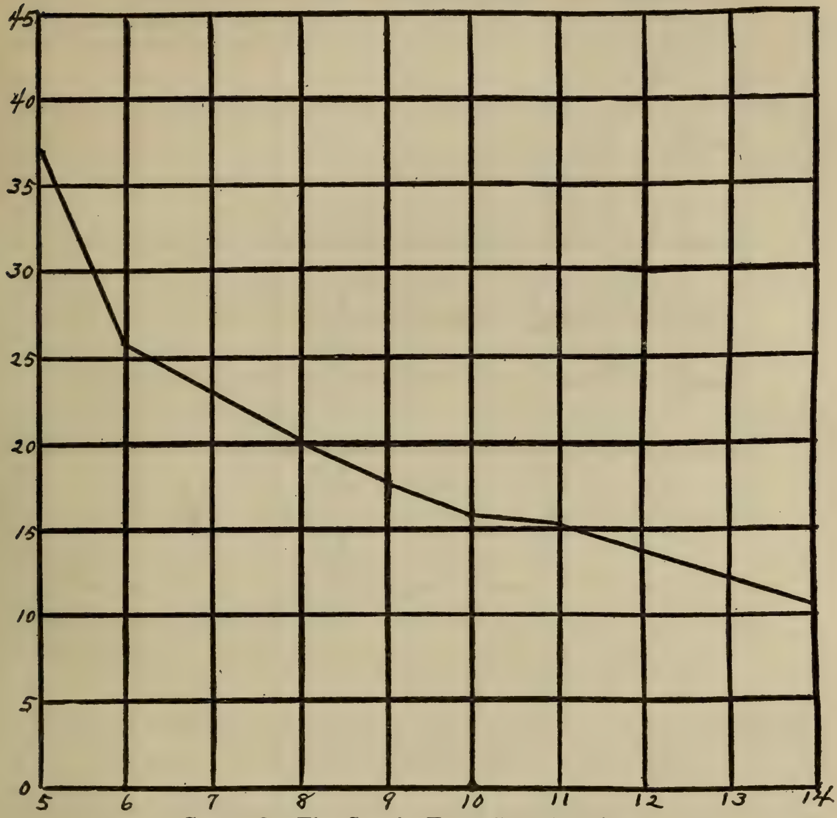


GRAPH 6. The Mare and Foal Test. Time.

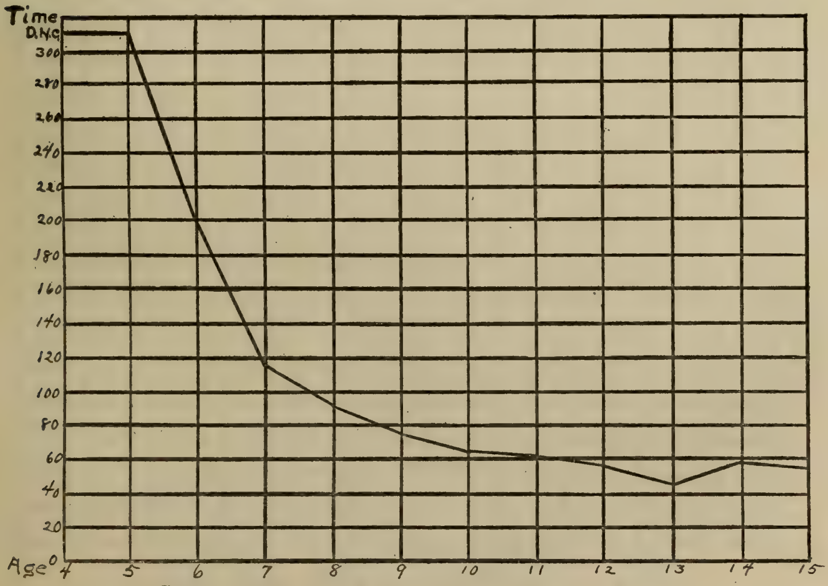


GRAPH 7. The Mare and Foal Test. Errors.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

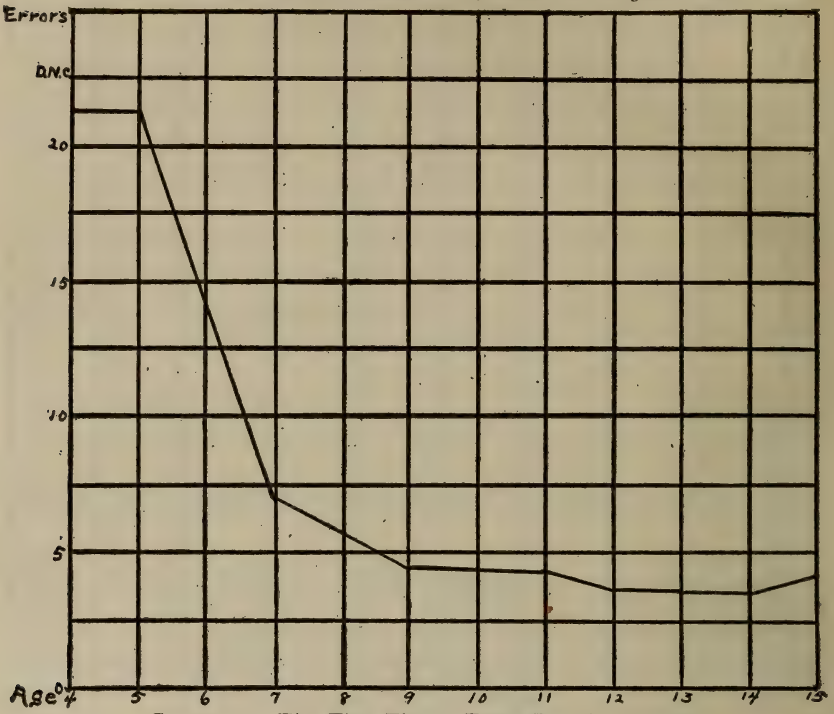


GRAPH 8. The Seguin Form Board. Time.

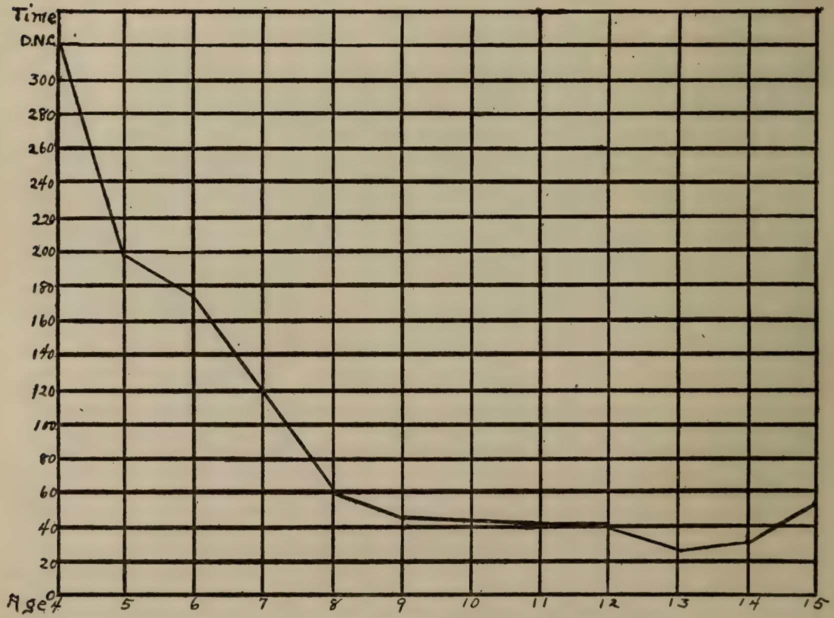


GRAPH 9. The Five Figure Form Board. Time.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

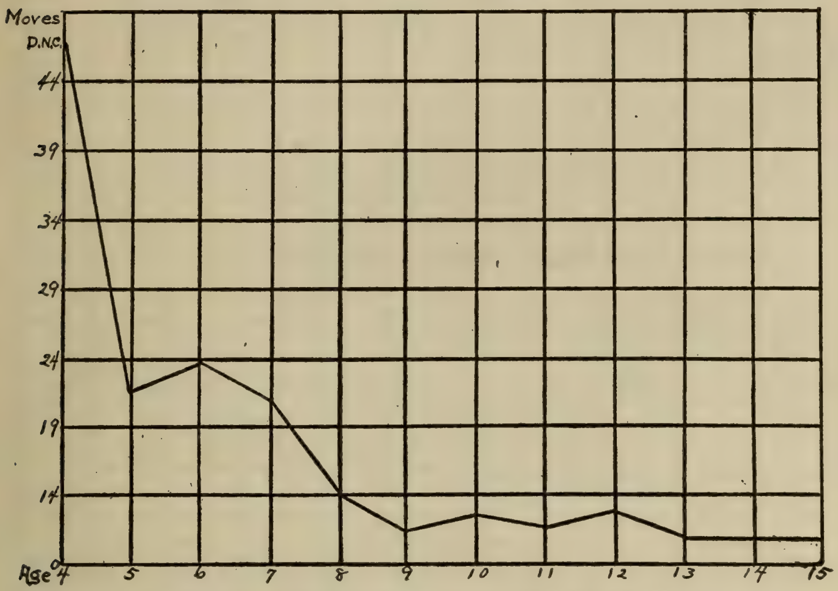


GRAPH 10. The Five Figure Form Board. Errors.

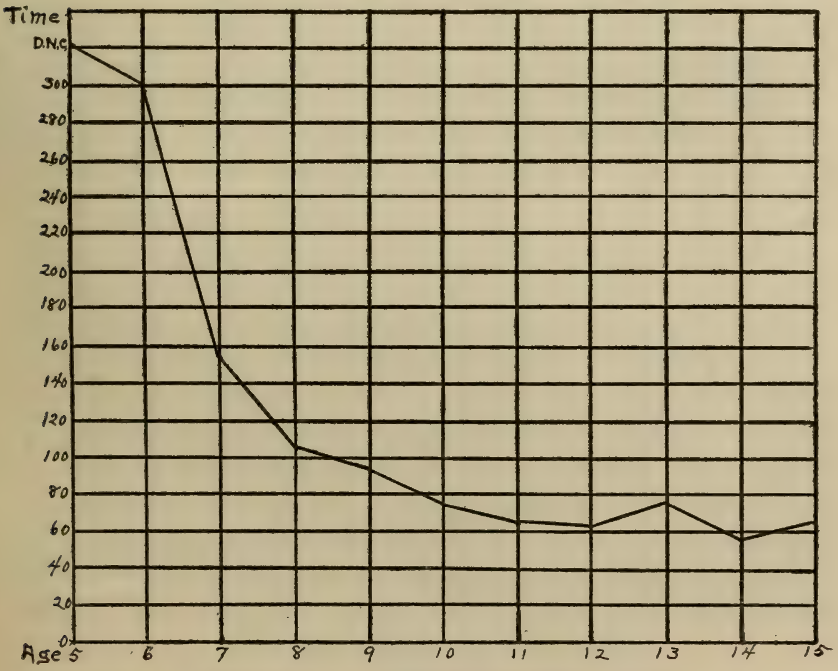


GRAPH 11. The Two Figure Form Board. Time.

Graphs from "A Scale of Performance Tests," Pintner and Patterson (Appleton, 1917). *The numbering follows the original text.*

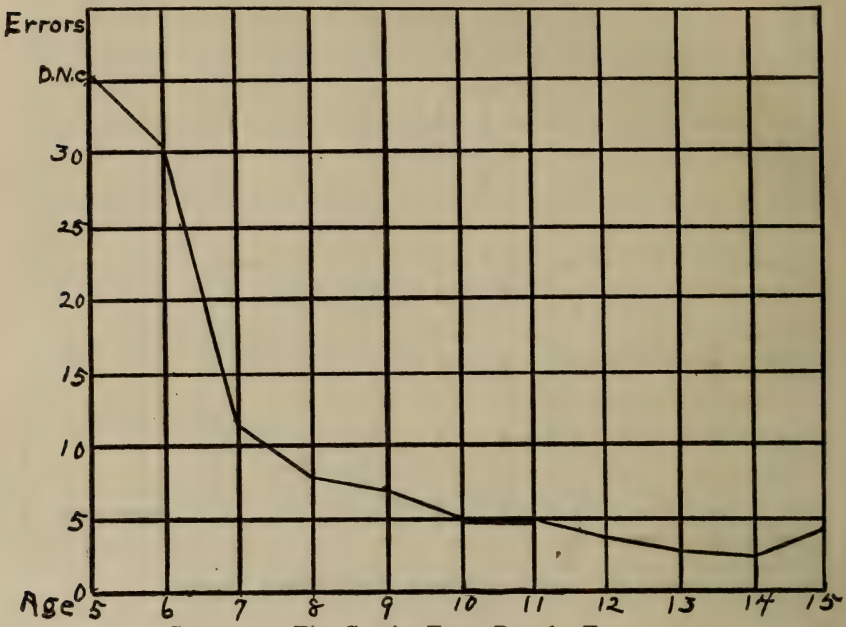


Graph 12. The Two Figure Form Board. Moves.

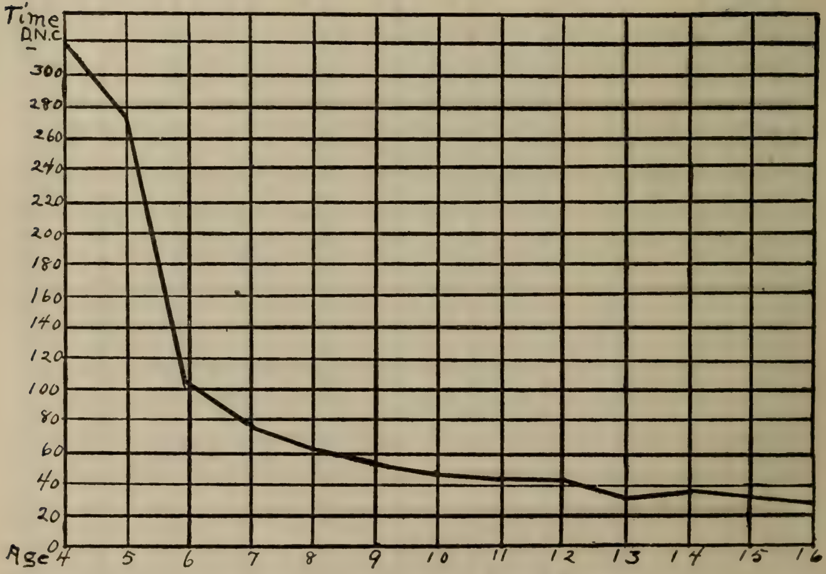


Graph 13. The Casuist Form Board. Time.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

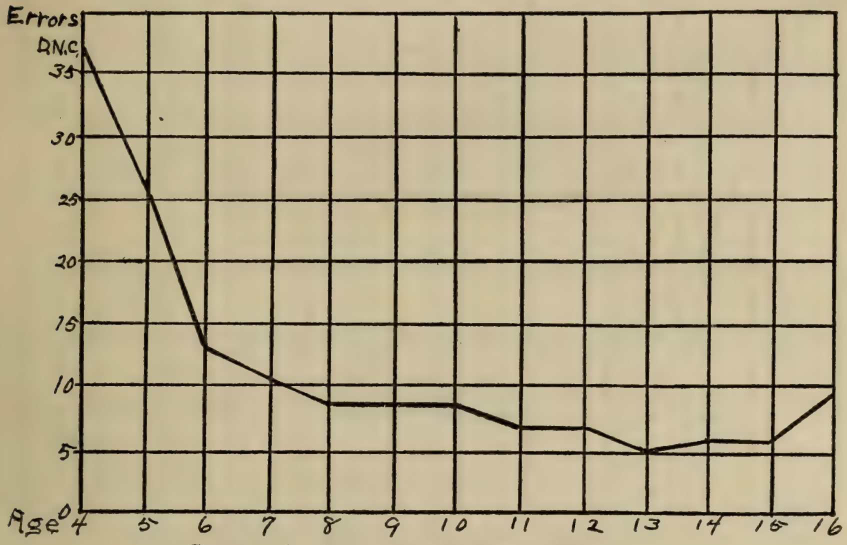


GRAPH 14. The Casuist Form Board. Errors.

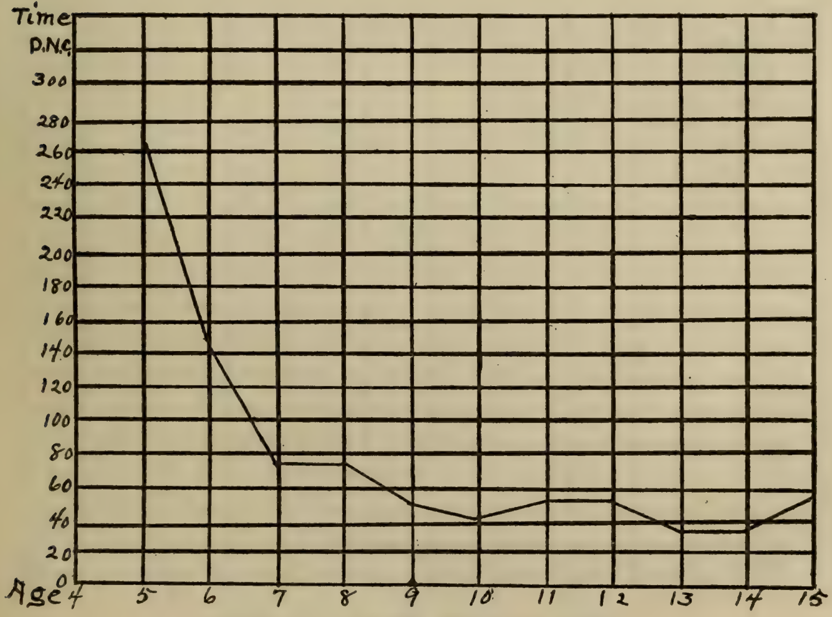


GRAPH 15. The Triangle Test. Time.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

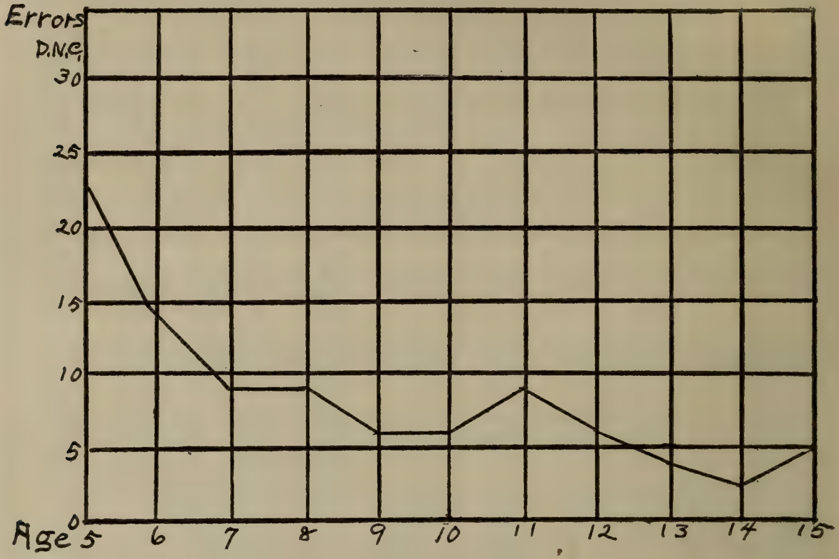


GRAPH 16. The Triangle Test. Errors.

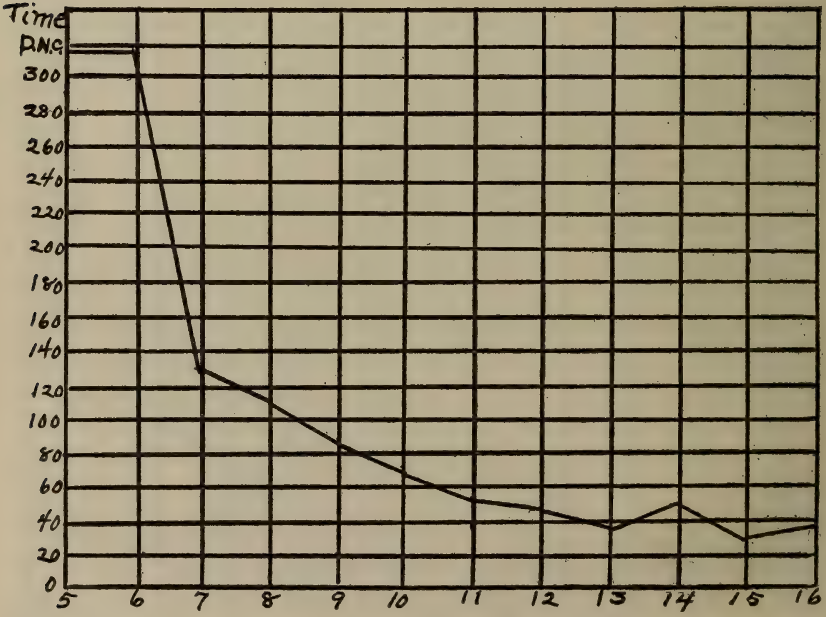


GRAPH 17. The Diagonal Test. Time.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

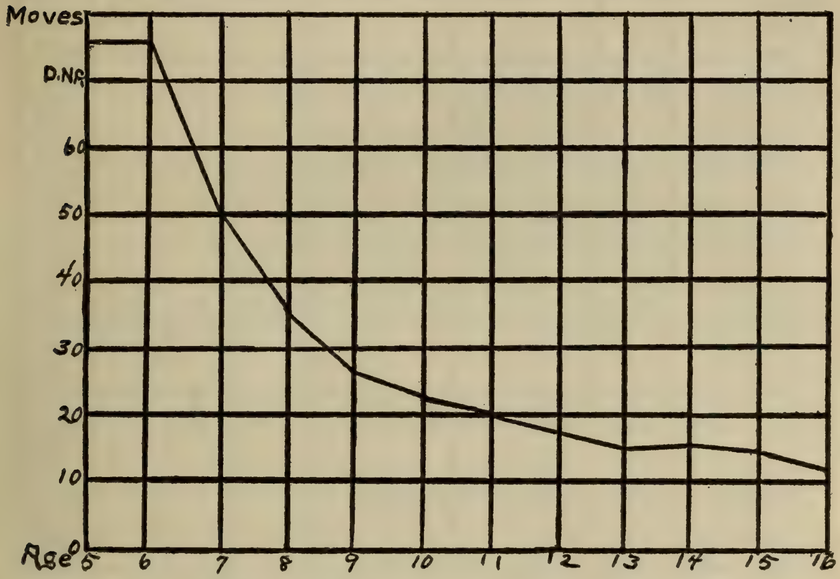


GRAPH 18. The Diagonal Test. Errors.

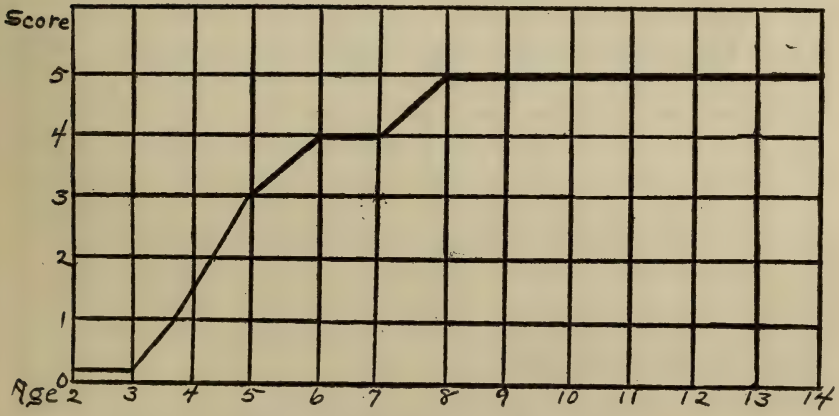


GRAPH 19. Healy Puzzle "A." Time.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

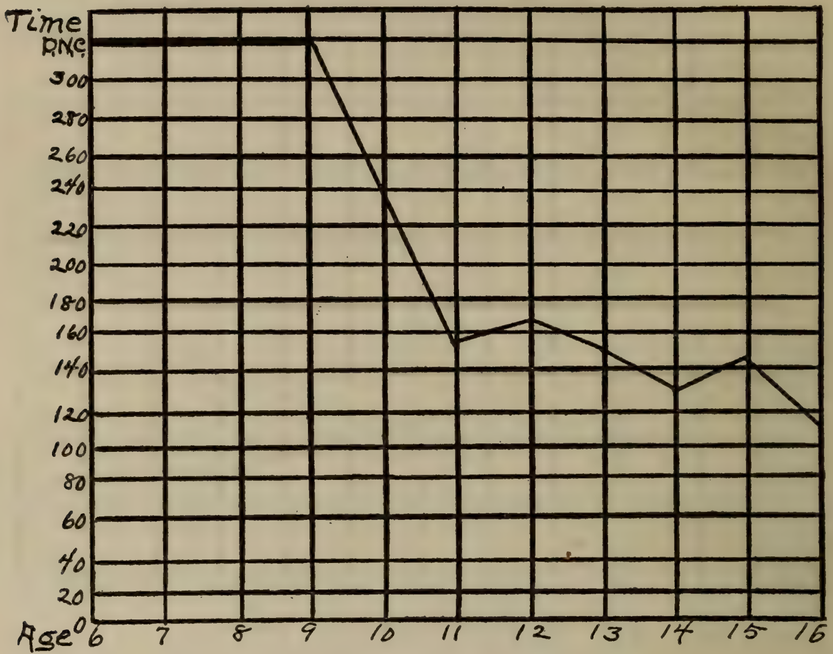


GRAPH 20. Healy Puzzle "A." Moves.

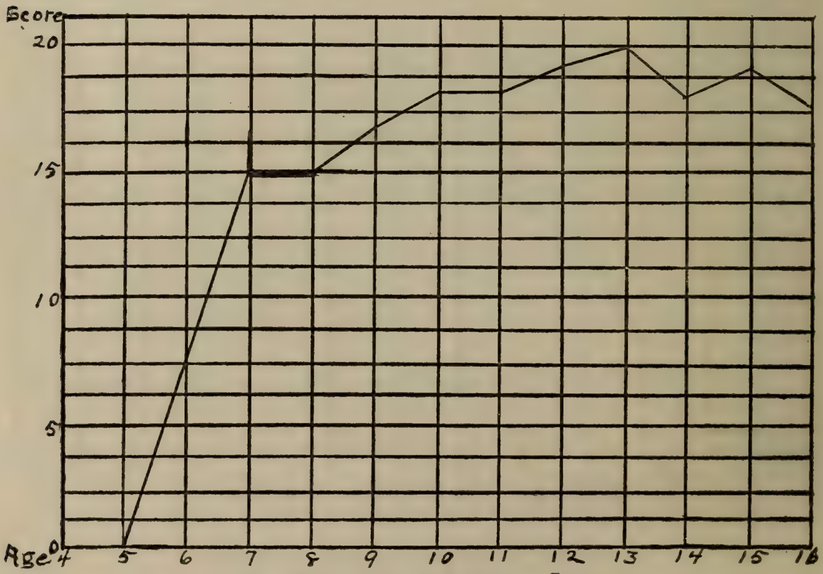


GRAPH 21. The Mannikin Test. Score.

Graphs from "A Scale of Performance Tests," Pintner and Patterson (Appleton, 1917). *The numbering follows the original text.*

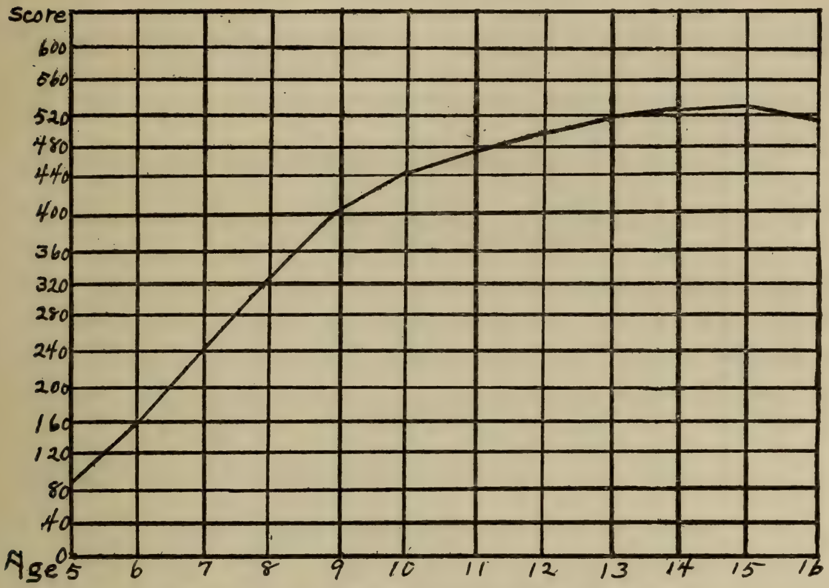


Graph 22. The Feature Profile Test. Time.

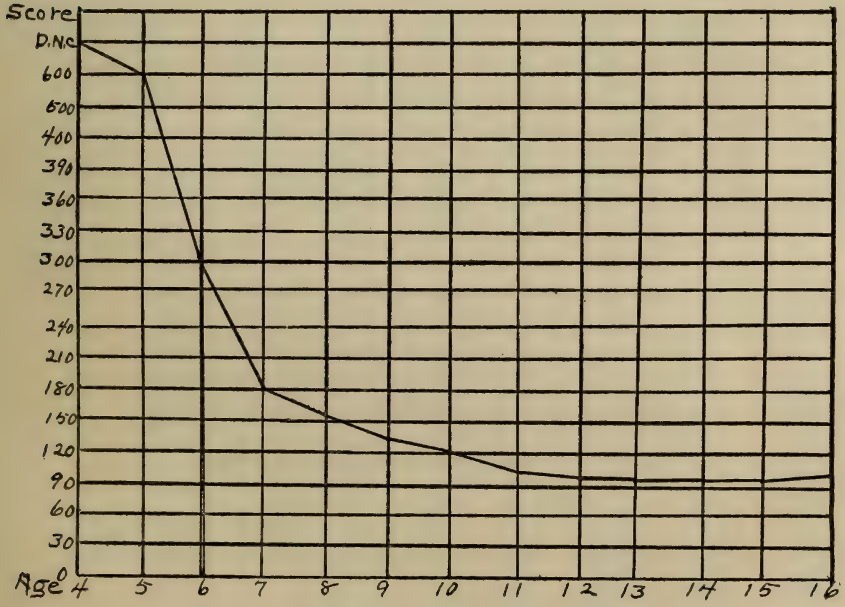


Graph 23. The Ship Test. Score.

GRAPHS FROM "A SCALE OF PERFORMANCE TESTS," PINTNER AND PATTERSON (APPLETON, 1917). *The numbering follows the original text.*

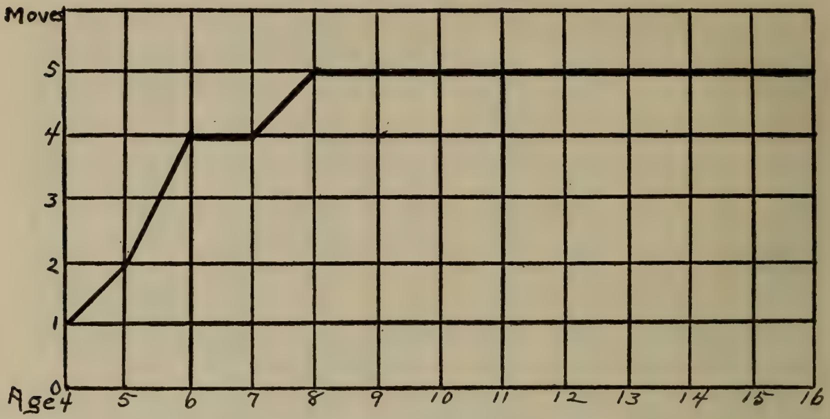


GRAPH 24. The Picture Completion Test. Score.

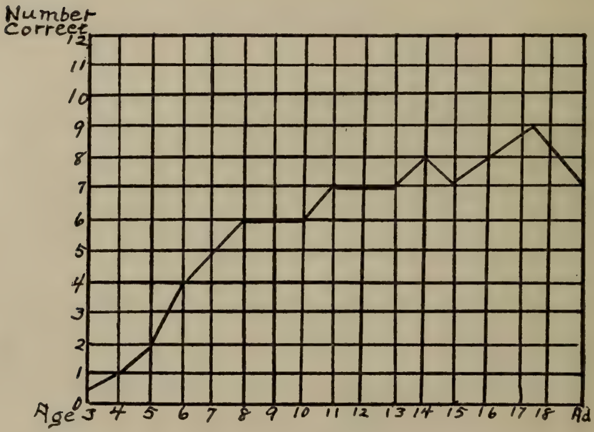


GRAPH 25. The Substitution Test. Score.

Graphs from "A Scale of Performance Tests," Pintner and Patterson (Appleton, 1917). *The numbering follows the original text.*



Graph 26. The Adaptation Board. Moves correct.



Graph 27. The Cube Test. Lines Correct.

D. ILLUSTRATION FROM PERFORMANCE TEST MATERIAL DEVELOPED BY HEALY.

The Healy performance tests show tendencies similar to the other tests of the same type. However, the main use made of Healy's work here will be as a basis for discussion of the relative failure of adults with performance material, and the significance of this fact to the theory of intelligence levels. The following quotation, beginning on page 200 of the monograph, "A Pictorial Completion Test",* is in point:

"The older individual is prone to meet a simple situation with the idea that there must be something back of it. . . . The 'might be' of the adult with his greater stock of ideas is very rarely heard from the child. . . . Of course the chicken 'might be' jumping at the cat, or at the bird in the cage. The greater experience of adults led them to perceive many more possibilities in the situation than the child sees. It may be this, rather than any conscious attempt at criticism which leads the adult to go much farther than taking the picture at its barest face values."

This all means that the normal adult is inclined to inject abstraction into the situation, and to refuse to deal exclusively with the simple concrete which is before him. He puts in much more than he sees. He does poorer work on the tests because his mind really works better. If he cannot put in the extra abstraction, he is not a normal adult, his mind is retarded on the level of the concrete, the predominating level of the child-mind. Below is a table based upon examination of 95 college people with the Healy Picture Completion Test.

THE WELLESLEY DATA†

I. Cases with no errors	
Wellesley	26%
Private School	30%
Delinquents (B Group)	33%
Delinquents (A Group)	40%

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*Psychological Review, XXI, 3.
†Psychological Review, XXI, 3.

II. Percentage of total errors to pieces placed

Wellesley	21.7%
Private School	15.0%
Delinquents (B Group)	10.0%
Delinquents (A Group)	6.0%

III. Percentage of total errors illogical

Wellesley	64.0%
Private School	50.0%
Delinquents (B Group)	40.0%
Delinquents (A Group)	33.0%

The evidence of poorer work on the part of the college students in the strictly perceptual part of the problem is here very evident. If the suggested reason for it is the true one, however, the poor showing is a recommendation rather than otherwise. Even the high per cent of illogical error as judged in perceptual terms, becomes logical when judged in abstract terms, and therefore becomes a recommendation rather than a fault. These data, therefore, are understandable on the theory that the one who can get the most out of a perceptual test is the one who has not developed beyond the perceptual level. He does not have the great stock of abstract ideas to bother him, and consequently he saves time by direct and naïve solution of the concrete situation. Perhaps the best way to make a performance test indicate truly the intelligence of the adult would be so to regulate it that the number of original, but proved logical, solutions would determine the score. Then the adult would not be penalized for his higher type of intelligence as he now is in such tests. (Pintner and Patterson, working with the Knox tests with children, were obliged to set higher limits of achievement and time than those used by Knox with adults.)—See discussion at several points in "A Scale of Performance Tests", by Pintner and Patterson. (Appleton, 1917.)

E. ILLUSTRATIONS FROM STUDIES DIRECTED TOWARD THE DETERMINATION OF THE TYPE OF MENTAL FUNCTION POSSESSED BY THE FEEBLEMINDED.

A very good illustration is found in the excellent study by Cyrus D. Mead, Ph.D., Teachers' College Contribution to Education, No. 76, on "The Relations of General Intelligence to Certain Mental and Physical Traits". The reader is referred to Dr. Mead's monograph for the conclusive data back of the assertions made in the following quotation concerning the relative perceptual and memory powers of the feebleminded and the normal child.

Page 78, line 3: "As a practical suggestion from the above data, and with a firmer conviction after six years of experience in the education of hundreds of mentally defective children, the author would offer the point that in the ability to perceive and to memorize defective children do better than in any other of the purely mental traits. It makes less difference with these children whether the material has relationship than it does with normal children. Memory seems to be a characteristic in itself, native perhaps. It is a common occurrence to have defective children call their teacher's attention to any slight change in the latter's dress. The powers of perception and memory then should be used to the utmost in the education of these children. The most practical contribution made by Miss Norsworthy in her study is quoted: 'To speak of (defectives) them as being equally deficient in all the mental powers is false. . . . From the point of view of the psychologist and the educator it is fully as important to know that the (defective's) perceptive powers are almost two and a half times as strong and accurate as his intellectual powers, and almost half as strong again as is his powers of memory, as to know that he is weaker than the ordinary child in all of these particulars.' "

Three things here are evident: (1) that defective children do not possess the higher mental functions to the degree that these functions are possessed by normal children; (2) that they possess memory and perception to a very considerable degree; and (3) that they tend to fail in the power to note relationships between the memories and percepts which they really possess.

Another illustration may be drawn from the pamphlet by Knox on "Alien Mental Defectives" (Stoelting, Chicago). In this pamphlet is a study entitled, "A Comparative Study of the Imaginative Power in Mental Defectives". Again the reader is referred to the article itself for the data which are too detailed to reproduce here; but the conclusions are significant. (The test was the common "Ink Blot" test.) Dr. Knox says:

"(1) It is apparent from a study of the tables that there are no Jules Vernes among the twenty-five defectives, at least, and, as compared to the twenty-five normals, there is very little ability to draw mental pictures from commonplace or amorphous objects. (2) The associations among the defectives are for the most part not logical. . . . (4) The reaction-time was nearly twice as long in the defectives as in the normals. . . . (5) Tests of imagination and the average reaction-time to questions may be valuable points to consider when dealing with mental defectives from a diagnostic standpoint."

This quotation, and its supporting data, reinforce the point of the previous quotation that the imaging ability of the feebleminded is less than their perceptive ability, and that their logic, or judgment, is the least of all of their abilities.

F. ILLUSTRATIONS FROM SUCCESS AND FAILURE IN ABSTRACT AND CONCRETE SUBJECTS OF INSTRUCTION.

In an article by Cummins in "The Journal of Educational Psychology", October, 1919, there appears a comparison of "bright" and "slow" pupils. In the process of this study there is developed the following with relation to the relative difficulty of studies:

"By dividing the number of cases in which high marks were received, by the number of cases in which low marks were received, the ratios thus obtained give us a fair picture of the relative difficulty of each subject. Arranging the subjects in the order of these ratios from the highest to the lowest, we have the following array:

Physical Training	14.67
Arts (Domestic and Fine)	5.25
Shop (Manual Training, etc.)	3.00
English and History	1.56
Modern Language	1.42
Science	.92
Ancient Language	.46
Mathematics	.19

Thus there appears an almost perfect gradation all the way from the subject which is almost wholly a matter of ideo-motor coördination, to the subject which involves the largest amount of abstract thinking. The only possible exception is that of ancient language which should no doubt have occurred in the array following the modern languages."

It is true that, since this relationship of studies is based upon marks received, the reason for the greater number of high marks received in physical training, etc., and the frequency of low marks in mathematics, etc., may have been the different marking standards of different teachers. But it is improbable that the sequence in the array from concrete to abstract would have been anywhere nearly so perfect unless it was at least somewhat determinded by the real character of the subjects as well as by the personal equation of the person giving the marks. The conclusion from the data presented that abstract studies are relatively harder (require more intelligence) is a relatively safe one.

Other illustrations of this point might easily be produced. Some material taken from "The Illinois Survey" (Published 1917 by the Illinois State Teachers' Association), will suffice.

TABLE VIII—SEC. 10

Median Proportion of Pupils in Each Grade, Page 124, Reported as "Finding Difficulty in Completing Required Work".

Grade	No. of Teachers Reporting	Median Proportion of Pupils "Finding Difficulty".
I	192	6%-10%
II	124	6%-10%
III	102	11%-15%
IV	116	6%-10%
V	112	6%-10%
VI	114	6%-10%
VII	111	6%-10%
VIII	109	6%-10%

Note.—Because of certain reasons the extra percentage in grade III is not considered especially significant.

In Terman's "The Measurement of Intelligence", p. 78, there is a table showing that in an unselected group of persons of a reasonably large number, the intelligence quotients of the lowest ten per cent will be 85 or below. It is reasonably safe to suppose that the children under consideration by these Illinois teachers represented such an unselected group, and that those reported as "finding difficulty" were largely those of approximately 85 I. Q. or below, since the 6 per cent to 10 per cent reported would be constituted of just about the low I. Q.'s in question. The following table from the same survey gives further light upon the matter.

TABLE IX—SEC. 1, PAGE 125

Subjects in Which Pupils Find it Difficult to Complete the Required Work.

34.60% of teachers reporting name	reading
18.15% of teachers reporting name	arithmetic
17.46% of teachers reporting name	language
17.26% of teachers reporting name	geography
13.84% of teachers reporting name	spelling
12.79% of teachers reporting name	grammar
10.70% of teachers reporting name	history

On page 143 of the same book is found the following:

"The subjects in which the greatest difficulty is experienced, varies from grade to grade. In general, arithmetic may be looked upon as the most difficult subject as measured by the standard represented in Table IX (teachers' judgments), and the difficulty of this subject is sustained throughout the grades, from the third to the eighth."

It is clear that these teachers found the poorest 10 per cent of the children (almost certainly children of low I. Q.) having trouble with the abstract subjects. Not a single one of the more perceptual subjects is mentioned. Again the result might be due to excessive requirements in the subjects named, and the light requirements in the other subjects; but the chances are all in favor of the assumption that the type of subject, abstract or concrete, is at least partially the determining factor. Another table from the same survey is interesting in this connection.

Something of the same progression from concrete to abstract is seen in Table XVII. The assumption is possibly a fair one that teachers would, in matters of promotion, disregard those subjects which they do not consider to be very good tests of a child's general ability.

In this same survey there is a study of "Some Exceptional High School Pupils in Illinois" by E. E. Jones. He shows that

TABLE XVII—PAGE 140

Subjects Disregarded in Determining Promotion.

Subject	Proportion of 1407 Teachers Reporting Subject as Disregarded
Music	67.3
Drawing	65.4
Writing	31.4
Physiology and Hygiene	10.2
Manual Training	9.1
Physical Training	9.1
Spelling	8.1
Arithmetic	2.8
Reading	2.8
History	2.7
Language	2.0
Geography	1.9
Grammar	9.5

these pupils did all round good work in the grades and did not drift toward any particular line of work. They were not pushed early into manual training or other hand work. They had general ability; and this general ability showed in the high school as well as in the grades. The pupils tended to be good in everything that they undertook. And yet the author says that he found no reason why these persons excelled. Is it not clear that they excelled because they had good general endowment—in ability to deal with the abstract as well as in ability to deal with the concrete?

CHAPTER V

THE FUNDAMENTAL NATURE OF INTENTIONAL ADAPTATION (CONTINUED).

I. Original quantitative studies.

1. In upper school grades.

Attempts made by the writer to test the hypothesis of levels in intentionally controlled intelligence have been guided by the conclusion that if the theory in question is true, then the achievement of high and low intelligence should be nearest together on the perceptual level where all tend to be more equally endowed, and farthest apart on the symbol level, upon which low intelligence finds it hard to act at all. (To leave out the image level accents the contrast of the extremes.)

In this upper grade study the first step in quantitative determination was that of ascertaining the general intelligence of a chosen group so that the result could be used as a criterion for checking further work. For this purpose the Binet-Simon tests were chosen as the best available instrument. It is true that these tests themselves show a gradation from perceptual material to symbol material, and that, at first glance, it might seem that to use them as a criterion in attempts to prove the existence of levels based upon the same principle, would be to reason in a circle. On the contrary, the exact reverse is the case. When the authors devised these tests they made use of a purely trial and error method. They experimented with very numerous "stunts" of all descriptions and the separate tests really located themselves. They fell into certain relative positions and relationships because as a result of their fundamental nature they could occupy no other positions and relationships. After they had assumed those relationships, and so had become a scale for the measurement of intelligence, that scale was checked by criteria of all kinds, such as estimates of intelligence, school work, school progress, experience in life, etc., etc.; and it is now generally admitted to be the best instrument for getting at an approximation to exact quantitative measurement of intelligence. If one accepts the scale as it is and examines it with the purpose of discovering the factor responsible for the self-arrangement of the individual tests, one is forced to conclude that this responsible factor lies in differences in amounts of perceptual and symbolic material utilized at various levels. Thus these tests themselves supply a certain amount of confirmation of the hypothesis for which proof is sought, and they have already been so cited.

But one can go farther. For example, if one makes brick and gets an especially excellent quality, he may examine all conditions of the process and try to decide upon the factor responsible for the excellence. Then he can vary that factor, compare with the original results, and so test his opinion as to the factor's responsibility for the excellence. The intention has been similar in the present instance. The start is made on the theory of the responsibility of the proportions of the perceptual and symbol materials, those proportions are varied, and the results are examined for light upon the theory.

An abbreviated form of the Binet-Simon tests (the starred tests of the Stanford Revision) was given to 364 children in grades four to eight, inclusive, of a normal training school. Table I shows the raw data of this study.

TABLE I

Original Data: Abbreviated Binet and Teachers' Estimates of Intelligence.
Eighth Grade.

Case	Born	Tested	M.A.	1st Est.	2nd Est.
1	10/18/03	3/ 4/19	14- 2.5	5	4
2	12/24/04	2/25/19	14- 7.5	4	4
3	11/16/04	2/25/19	15- 4.5	4	4
4	12/29/05	2/28/19	16- 0	4	4
5	1/26/05	2/26/19	17- 4.5	3	3
6	9/14/03	2/25/19	15-10.5	3	3
7	10/17/02	3/ 4/19	13- 0	6	5
8	12/ 4/03	3/ 4/19	13- 9.5	6	5
9	5/ 6/05	2/26/19	15- 2	4	3
10	8/23/04	2/25/19	16- 7.5	4	3
11	6/13/03	2/27/19	14- 8	4	5
12	9/ 9/03	2/26/19	15- 9.5	5	4
13	11/25/03	3/ 4/19	12- 7.5	6	5

TABLE I (Continued)

Eighth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
14	1/11/05	2/26/19	15-10.5	1	3
15	6/28/01	3/ 4/19	11- 4	6	6
16	3/ 1/04	2/28/19	13- 9.5	4	4
17	5/19/05	2/27/19	13- 7.5	3	4
18	3/ 6/04	2/28/19	15- 4.5	3	4
19	9/17/03	2/27/19	13- 7.5	4	4
20	4/ 9/03	2/25/19	12- 8	5	5
21	8/ 2/02	3/ 4/19	13- 7	6	5
22	7/17/05	2/28/19	15- 5.5	4	4
23	3/30/05	2/26/19	14- 5	4	4
24	11/16/04	3/ 4/19	13- 2	4	5
25	10/28/01	3/ 4/19	11- 4.5	5	6
26	8/21/03	2/28/19	12- 6	5	5
27	3/ 9/03	3/ 4/19	12- 8	6	5
28	3/18/05	2/25/19	13- 1.5	3	4
29	9/18/05	2/26/19	16- 0	1	1
30	10/ 1/03	2/27/19	13-11.5	4	4
31	5/14/05	2/26/19	14- 5	4	4
32	5/18/03	3/ 4/19	12- 7.5	6	6
33	7/20/04	2/28/19	13- 9	4	4
34	11/24/04	3/ 4/19	16- 7.5	3	3
35	12/ 4/02	2/26/19	13- 1.5	4	4
36	4/ 2/02	3/ 4/19	13- 3.5	7	7
37	8/29/04	3/ 4/19	14- 2	4	4
38	2/18/06	2/25/19	15- 6	1	1
39	2/12/01	3/ 4/19	15- 3	5	6
40	10/ 2/04	3/ 4/19	14- 3	5	5
41	11/ 8/05	3/ 4/19	15- 3	4	4
42	1/29/06	3/ 4/19	14- 4.5	4	4
43	11/ 2/00	4/ 9/19	13- 3.5	6	6
44	2/ 5/06	3/ 4/19	16-10.5	4	3
45	11/ 2/04	3/ 4/19	14- 9	3	3
46	6/16/06	3/ 4/19	18- 1.5	2	1
47	1/19/05	3/ 4/19	16- 7.5	3	4
48	6/ 8/04	3/ 4/19	15- 9.5	4	4
49	2/ 8/06	3/ 4/19	15- 4.5	4	4
50	8/ 2/04	3/ 4/19	14- 3	4	3
51	12/25/02	3/ 3/19	15- 8	6	6
52	12/15/04	3/ 4/19	13- 2	5	4
53	7/11/05	3/ 3/19	14- 7.5	4	4
54	3/22/05	3/ 4/19	14- 1.5	6	6
55	8/14/03	3/ 4/19	16-10.5	4	4
56	5/29/04	3/ 4/19	13- 8.5	6	6
57	2/15/07	3/ 4/19	16- 1.5	2	2
58	10/13/05	3/ 4/19	17- 4.5	2	2
59	10/ 6/05	3/ 4/19	13-11	5	5
60	8/ 4/03	3/ 4/19	15- 1.5	5	5
61	12/12/02	3/ 4/19	14- 6	6	6
62	12/ 9/03	3/ 4/19	13- 9.5	5	5
63	11/23/02	3/ 4/19	12- 8.5	6	6
64	3/ 2/05	3/ 4/19	12- 6	4	4
65	5/20/05	3/ 4/19	14- 7.5	4	4
66	12/23/05	3/ 4/19	12- 8.5	4	4
67	2/22/04	3/ 4/19	15- 6	4	4
68	6/24/07	3/ 4/19	15- 4.5	4	4

TABLE I (Continued)

Eighth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
69	11/ 6/04	3/ 3/19	14- 4.5	4	4
70	5/22/04	3/ 4/19	16- 0	5	5
71	10/ 4/04	3/ 4/19	11- 8	5	5
72	2/18/04	3/ 4/19	13- 6	5	5
73	9/15/05	3/ 4/19	14- 5	4	4
74	3/11/06	3/ 4/19	16- 0	4	4
		Seventh Grade			
1	6/ 9/05	3/ 4/19	16- 0	4	4
2	9/20/05	3/ 4/19	14-10.5	4	4
3	3/ 7/06	3/ 4/19	15- 9	3	2
4	1/ 1/04	3/ 4/19	14- 0.5	4	4
5	5/13/05	3/ 4/19	16- 0	3	3
6	10/12/02	3/ 4/19	14-10	4	3
7	11/ 9/05	3/ 4/19	14- 7.5	3	3
8	11/23/03	4/11/19	13- 2	5	5
9	6/ 4/05	3/ 4/19	15- 6.5	3	3
10	7/23/07	4/11/19	16- 1.5	3	3
11	1/20/05	3/11/19	15- 7.5	4	5
12	12/ 7/05	3/ 4/19	16- 0	4	3
13	9/24/06	3/ 4/19	15- 4.5	3	2
14	12/ 8/03	3/11/19	14- 3	5	5
15	12/15/04	3/ 4/19	14-10.5	4	5
16	3/ 7/05	3/ 4/19	14- 7.5	4	4
17	12/ 8/05	3/ 4/19	18- 9	2	2
18	2/29/04	3/ 4/19	9- 4	7	7
19	11/ 9/04	3/ 4/19	13- 3.5	4	4
20	7/13/04	3/ 4/19	16- 0	5	5
21	8/13/04	3/11/19	12-11.5	4	4
22	12/16/05	3/ 4/19	14- 6.5	4	4
23	6/17/05	3/ 4/19	13- 6.5	4	4
24	9/29/05	3/ 4/19	16- 1.5	3	3
25	1/22/07	3/ 4/19	14- 4.5	3	3
26	8/20/04	3/11/19	15- 7.5	4	5
27	12/20/05	3/11/19	12- 2	3	4
28	5/31/04	3/11/19	14- 1.5	5	5
29	11/16/03	3/11/19	14- 0	4	4
30	12/ 3/05	3/11/19	15- 3	3	4
31	1/12/06	3/ 4/19	13- 1.5	4	4
32	10/22/05	3/ 4/19	12- 5.5	4	5
33	11/26/05	3/ 3/19	16-10.5	3	4
34	10/23/03	3/11/19	12- 9	4	4
35	11/13/05	3/ 4/19	14- 3	4	4
36	3/23/06	3/ 4/19	15- 2	4	4
37	4/15/04	3/11/19	13- 0	4	4
38	3/12/05	3/11/19	12- 2	5	6
39	6/22/05	3/11/19	15- 0	4	6
40	9/ 2/06	4/18/19	12- 0	4	4
41	3/14/04	3/11/19	15- 0	4	4
42	7/15/05	3/11/19	16- 0	4	4
43	7/15/05	3/11/19	12- 8	4	4
44	12/20/04	3/11/19	12-10	4	4
45	12/ 3/06	3/ 4/19	15-10.5	2	2
46	10/ 4/05	3/11/19	12-11.5	4	4
47	6/18/05	3/11/19	10-10	4	4

Table I (Continued)

Seventh Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
48	6/11/07	3/11/19	17- 4.5	2	2
49	1/ 5/06	3/ 4/19	12- 0	4	4
50	12/17/06	3/ 4/19	13-11	2	2
51	10/20/03	3/11/19	11- 4	6	5
52	3/22/06	3/ 4/19	14- 9	2	2
53	7/20/05	3/11/19	13- 6.5	4	4
54	2/13/05	3/11/19	11- 8	5	5
55	4/20/05	3/ 4/19	11- 8	5	5
56	2/16/07	3/11/19	14- 9	3	3
57	12/ 8/05	3/11/19	12- 4	4	4
58	1/11/06	3/11/19	14-10	4	4
59	7/ 4/06	3/ 4/19	13- 3.5	3	2
60	6/ 7/06	3/11/19	15- 4.5	4	4
61	11/25/05	3/11/19	15- 0	4	4
62	6/13/06	3/11/19	11-10	4	4
63	2/ 6/05	3/11/19	12- 4	4	4
64	10/19/05	3/11/19	12- 4	4	4
65	7/29/06	3/11/19	16- 3	4	4
66	4/ 3/06	3/ 4/19	14- 3.5	4	4
67	12/19/07	3/ 4/19	13- 7.5	2	2
68	1/13/07	3/ 4/19	16- 3	2	3
		Sixth Grade			
1	8/ 6/06	3/11/19	12- 4	4	6
2	7/19/04	3/11/19	11-10	6	6
3	4/28/04	3/11/19	14- 7.5	5	4
4	6/12/06	3/27/19	13- 7.5	4	3
5	8/ 7/06	3/11/19	13- 9.5	5	4
6	7 /7/06	3/11/19	12-11.5	4	4
7	8/17/04	3/11/19	12- 4	4	4
8	1/26/05	4/11/19	12- 0	3	3
9	2/15/06	3/11/19	12- 4	5	3
10	8/ 7/07	4/11/19	16- 3	2	2
11	4/ 2/03	3/28/19	13- 4	6	5
12	12/23/02	3/11/19	12- 0	6	7
13	9/10/06	3/11/19	12- 8	4	5
14	1/ 5/06	3/11/19	12- 5	4	5
15	2/ 7/06	3/11/19	11- 7	4	4
16	4/ 4/06	3/11/19	13- 9.5	4	4
17	1/ 4/06	3/18/19	13- 0	5	5
18	2/ 1/07	3/11/19	11- 0	5	5
19	12/29/07	3/11/19	14- 1.5	2	2
20	3/ 1/06	3/18/19	13- 9	4	5
21	12/15/07	3/11/19	11- 6	4	5
22	1/ 5/06	3/11/19	15- 7.5	2	2
23	9/ 8/06	3/11/19	13- 4	5	4
24	4/27/08	3/11/19	15- 8	2	2
25	4/24/07	3/11/19	16- 1.5	2	2
26	11/25/04	4/14/19	11- 4	7	5
27	9/13/05	3/11/19	9- 9	6	5
28	1/ 9/05	3/27/19	13-11	3	3
29	5/26/06	3/27:19	12-11	5	4
30	2/28/07	3/11/19	12- 8	6	6
31	2/20/27	3/11/19	14- 6	1	1
32	3/ 6/06	3/25/19	12- 8.5	5	5

TABLE I (Continued)

Sixth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
33	6/ 3/06	3/12/19	13- 5.5	3	3
34	8/ 8/04	3/18/19	12-11	4	4
35	1/16/07	3/11/19	15- 0	3	2
36	8/25/07	3/11/19	15- 4.5	1	1
37	11/ 4/04	3/24/19	14- 3	2	2
38	5/16/06	3/18/19	13-11	5	5
39	9/27/06	3/18/19	11- 5	5	5
40	6/20/05	3/21/19	12- 1	5	5
41	9/27/05	3/17/19	14-10	2	3
42	3/17/06	3/17/19	15-10.5	2	3
43	2/ 7/07	3/11/19	12- 7.5	2	3
44	1/10/05	3/11/19	12- 6	6	7
45	3/ 6/06	3/24/19	15- 6	4	2
46	1/27/07	3/11/19	13- 7.5	4	3
47	7/ 6/06	3/18/19	14-10	4	3
48	3/ 3/07	3/11/19	10- 9	4	4
49	9/16/06	3/11/19	11- 2	5	4
50	7/15/05	3/18/19	11-10	4	5
51	5/18/07	3/11/19	14- 3.5	2	2
52	11/25/06	3/24/19	12-11.5	4	3
53	3/ 1/08	3/11/19	15- 7.5	2	1
54	5/12/06	3/31/19	15- 4.5	2	2
55	5/23/07	3/11/19	13- 9.5	3	3
56	2/ 9/08	3/27/19	10- 0	2	2
57	1/ 3/06	3/18/19	16- 7.5	2	2
58	9/30/07	3/20/19	13- 8	3	3
59	12/29/06	3/26/19	11- 9.5	6	6
60	5/31/06	3/27/19	12- 8	5	5
61	10/ 1/06	3/27/19	11- 4	5	4
62	7/10/07	3/24/19	11-10	5	5
63	7/25/07	3/18/19	14- 1.5	3	2
64	9/25/06	3/20/19	12- 5.5	2	4
65	6/ 5/07	3/24/19	15- 6	5	4
66	11/29/07	3/24/19	11- 4	4	4
67	11/19/06	3/21/19	11- 4	7	6
68	10/23/05	3/27/19	9- 6	6	4
69	6/ 4/07	3/24/19	12-11.5	4	4
70	2/ 7/05	3/24/19	11-10	6	4
71	11/10/05	3/24/19	14- 6.5	3	3
72	3/ 8/07	3/24/19	12- 4	2	3
73	10/27/04	3/24/19	10- 8	6	5

Fifth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
1	2/16/08	3/18/19	11- 8	3	3
2	10/ 4/06	3/20/19	12- 1.5	4	3
3	6/15/06	3/27/19	10- 9	5	5
4	3/ 4/06	5/13/19	10- 4	5	4
5	7/25/06	5/ 2/19	10- 2	5	5
6	9/17/06	3/27/19	11- 8	3	3
7	9/29/08	3/21/19	16- 3	2	2
8	5/11/08	3/18/19	11- 4	2	2
9	10/14/06	3/27/19	15- 9.5	4	4
10	5/ 5/06	3/18/19	15- 1.5	3	3
11	2/ 6/06	3/27/19	12- 3.5	4	5
12	7/ 2/04	5/ 5/19	10- 6	6	6
13	12/ 1/06	3/26/19	11- 3.5	4	4

TABLE I (Continued)

Fifth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
14	1/14/07	3/27/19	10- 8	4	4
15	10/27/04	4/29/19	11- 8	5	5
16	1/20/08	3/25/19	11- 0	4	4
17	10/ 3/06	3/27/19	10- 6	4	4
18	10/30/07	3/25/19	13- 6.5	2	2
19	4/15/07	3/25/19	13- 9	3	3
20	6/ 5/07	3/18/19	12-11.5	2	3
21	8/26/04	3/18/19	12- 7.5	5	6
22	2/20/09	3/25/19	15- 4.5	1	1
23	3/13/07	3/26/19	11- 8	2	3
24	3/13/08	3/18/19	11- 4	3	3
25	9/17/07	3/25/19	11- 0	4	3
26	7/11/07	4/30/19	11- 6	4	4
27	10/12/05	5/ 2/19	11- 6	4	4
28	1/24/09	4/30/19	13- 9.5	2	2
29	12/ 2/07	4/30/19	10- 9	3	4
30	10/28/07	5/ 2/19	12-11.5	3	3
31	8/22/05	5/ 2/19	12- 0	5	4
32	7/28/08	5/ 2/19	12- 2	3	3
33	6/19/08	5/14/19	11- 0	4	3
34	5/27/06	5/ 1/19	12- 3.5	4	3
35	6/13/07	4/29/19	12- 4	3	3
36	2/ 8/07	5/ 2/19	11- 1	4	4
37	3/ 1/08	5/ 3/19	12- 1.5	4	3
38	8/23/07	4/30/19	10- 8	5	4
39	7/ 7/07	4/30/19	12- 9.5	4	4
40	7/21/08	4/30/19	11- 5	3	3
41	4/28/08	5/ 2/19	13- 9	3	3
42	1/10/06	5/ 2/19	13- 4	4	4
43	5/15/04	5/ 5/19	9- 3	6	6
44	10/18/08	5/12/19	12- 3.5	4	4
45	9/18/07	5/ 2/19	12- 1.5	4	3
46	4/17/09	5/ 5/19	14- 5	2	3
47	7/ 2/08	5/ 2/19	12- 0	5	5
48	5/19/07	5/ 3/19	13- 5	4	4
49	2/ 1/09	5/ 2/19	12- 7.5	4	3
50	7/18/08	5/ 7/19	11- 8	4	3
51	3/23/06	5/ 6/19	10- 0	4	4
52	7/16/06	4/29/19	11- 4	5	5
53	2/22/07	5/ 7/19	11- 4.5	5	5
54	6/ 8/08	5/ 5/19	14-10.5	4	3
55	6/ 1/07	4/28/19	9-10	5	5
56	4/15/08	4/23/19	11-11.5	4	4
57	1/12/06	5/ 8/19	11- 3.5	5	5
58	4/ 3/09	5/ 5/19	10- 8	4	4
59	10/ 8/06	5/ 6/19	10- 8	5	5
60	10/17/07	5/ 6/19	11- 8	5	5
61	3/ 4/08	5/ 5/19	9-10	4	5
62	8/12/08	5/ 6/19	10- 0	4	5
63	3/29/09	4/23/19	9- 7	4	4
64	4/13/08	5/ 6/19	10-10	5	5
65	10/18/08	4/21/19	9- 6	6	6
66	7/10/08	5/ 2/19	11- 8	4	4
67	5/26/08	5/ 1/19	10- 5	4	3
68	2/20/08	4/28/19	10- 5	4	4
69	6/23/06	5/ 8/19	9- 8	5	5

Table I (Continued)

Fifth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
70	1/ 9/08	5/ 5/19	10- 8	5	5
71	9/30/08	5/ 2/19	17- 1.5	3	2
72	6/20/08	5/ 2/19	11- 0	3	3
73	11/19/08	5/ 7/19	11- 3.5	4	4
74	10/ 2/07	4/30/19	9- 7	5	5
75	2/22/08	5/ 3/19	11- 2	4	4
76	12/30/07	5/ 2/19	11- 8	4	4
77	1/29/07	5/ 1/19	11- 6	4	4
78	3/ 7/08	4/23/19	10- 6	5	5
79	4/30/07	5/ 5/19	10- 8	3	3
80	3/ 6/09	5/ 5/19	11- 4	4	3
81	10/23/07	5/ 5/19	10- 8	4	3
		Fourth Grade			
1	10/ 5/08	4/23/19	11- 5	5	5
2	10/27/08	4/29/19	9- 3	5	5
3	3/29/09	4/24/19	12- 6.5	2	2
4	4/ 9/08	4/28/19	11- 8	3	3
5	9/28/08	4/23:19	13- 3.5	2	2
6	8/23/08	4/21/19	11- 0	4	4
7	11/21/08	4/21/19	16- 4.5	1	1
8	11/11/07	5/ 7/19	13- 0	3	3
9	4/29/09	4/21/19	12- 7.5	3	2
10	1/25/08	4/29/19	11- 1	6	6
11	3/31/08	4/23/19	9- 9	6	6
12	6/ 5/08	4/30/19	12- 2	2	2
13	12/30/07	4/23/19	16- 0	2	2
14	5/19/07	5/17/19	13- 0	2	2
15	7/12/08	5/ 7/19	11- 0	3	3
16	12/13/06	5/ 6/19	9- 3	5	5
17	11/27/08	5/ 6/19	9- 3	5	5
18	2/22/10	5/ 7/19	13- 6.5	1	1
19	5/ 3/09	5/ 5/19	10- 4	4	4
20	2/12/07	5/13/19	11- 0	6	5
21	5/18/08	4/22/19	10- 2	6	6
22	5/ 4/07	4/29/19	9- 6	6	6
23	12/ 9/08	5/ 7/19	14- 9	4	4
24	7/24/08	5/ 7/19	11- 0	4	4
25	12/ 5/06	4/29/19	8- 6	5	5
26	8/26/04	4/21/19	10- 0	7	7
27	12/21/06	4/22/19	8- 9	7	7
28	10/ 6/07	4/23/19	8- 6	5	5
29	10/ 6/07	4/23/19	8- 6	6	6
30	9/ 7/08	4/29/19	12- 1.5	5	4
31	1/22/08	4/29/19	10- 4	5	4
32	5/14/08	4/22/19	9-11	4	4
33	6/13/09	4/23/19	11-11.5	4	4
34	8/27/09	4/22/19	9- 4	4	4
35	7/ 6/06	4/29/19	9-11	5	4
36	5/23/09	4/21/19	9- 6	3	3
37	4/22/09	4/21/19	11- 0	3	3
38	10/12/09	4/18/19	10- 8	3	3
39	5/ 8/08	4/14/19	10- 7	4	4
40	8/13/09	4/17/19	11- 6	2	2
41	1/ 9/08	4/22/19	9- 7	4	4
42	10/12/07	4/15/19	8- 9	6	7

TABLE I (Continued)

Fourth Grade

Case	Born	Tested	M.A.	1st Est.	2nd Est.
43	10/16/08	4/16/19	12- 5.5	4	3
44	2/16/09	4/15/19	8- 8	6	6
45	12/10/08	4/15/19	11- 0	4	4
46	5/24/10	4/16/19	10- 4	6	6
47	11/ 2/09	4/15/19	10- 7	6	6
48	7/11/08	4/15/19	9-11	5	5
49	10/29/08	4/21/19	10- 1	3	3
50	1/15/09	4/17/19	11- 7.5	3	3
51	9/12/09	4/30/19	10-10	4	5
52	7/ 2/08	4/30/19	10- 8	4	4
53	8/15/09	4/17/19	13- 3	2	2
54	12/13/09	3/26/19	12-10	2	2
55	4/29/09	4/21/19	10- 8	4	3
56	4/19/09	4/14/19	9- 6	4	4
57	12/29/09	4/17/19	10- 9	2	2
58	3/11/09	4/18/19	9- 6	3	2
59	12/12/08	4/18/19	10- 4	4	3
60	5/ 5/10	4/16/19	10- 2	5	5
61	7/11/09	4/17/19	8- 9	5	5
62	11/ 6/05	4/15/19	11- 0	7	7
63	6/29/08	4/17/19	11- 5	4	4
64	2/27/08	4/16/19	10- 1	4	5
65	11/11/07	4/21/19	9- 6	4	4
66	10/10/09	4/16/19	9- 9	5	5
67	2/ 3/09	4/16/19	9- 9	4	5
68	5/30/09	4/21/19	10- 1	4	5

Table II shows the distribution of the resulting intelligence quotients. (See page 79 for reason for selection of interval.)

TABLE II

Distribution of 364 Binet I. Q.'s.

— to 59	60 to 75	76 to 91	92 to 107	108 to 123	124 to 139	140 —
0	15	83	137	93	23	13

This table shows that the cases used constituted a very symmetrical distribution. This distribution was entirely the result of chance selection. The group below 60 I. Q. was not represented, of course, for intelligence of that grade is usually eliminated from the public school. The slight preponderance of high I. Q.'s was, perhaps, to be expected in the type of school which these children attend.

The work of determining the intelligence quotients was very carefully done. The tests were given partly by the writer and partly by other examiners, all of whom were trained by him. A common exact procedure was rigidly followed, the responses of the children were written down verbatim, and the writer rescored all papers as carefully and consistently as possible. Where known irregularities of any kind developed the test was discarded.

Previous experience in several schools led to a very careful checking of the chronological ages of the children before such ages were used as a basis for the computation of intelligence quotients. It is a common thing in any public school to find error in from 10 per cent to 15 per cent of records of chronological ages, even when such ages have been furnished by parents. This matter was followed up very carefully, the ages were obtained from two or three different angles, discrepancies noted, and personal work done to establish the facts.

After the intelligence quotients had been computed on the basis of the rescored papers, and the rechecked chronological ages, these quotients were checked by correlation with teachers' estimates of intelligence. For original data on estimates see Table II. The estimates had been obtained previous to the giving of the Binet tests. The procedure used in securing the estimates utilized the following instructions:

In estimating intelligence you are asked to grade on a scale of 1, 2, 3, 4, 5, 6, 7, as follows:

1 = Very superior
2 = Superior
3 = Somewhat above average
4 = Average
5 = Somewhat below average
6 = Inferior
7 = Very inferior

Be sure to take age into account. Compare the child with what you consider to be the average for children of his own age.

Avoid grouping your estimates in one or two groups. Ordinarily the *4* group (average) will be the largest single group. In the majority of classrooms *group 5* should be approximately equal to *group 3*, *group 6* equal to *group 2*, and *group 7* equal to *group 1*.

Your estimates will be held as absolutely confidential, therefore do not hesitate to place the child in the group where he belongs, however low that may be.

The teachers did not know that they would be asked to make these estimates again; but about one week later they were asked to repeat the process, rating each child with no opportunity for comparison with the former rating. Then Pearson correlations were made for each grade (1) between Binet I. Q. and the grade teacher's first estimate of intelligence, and (2) between Binet I. Q. and the same teacher's second estimate of the same pupils. The results of these correlations are shown in Table III. The coefficients are relatively high, due perhaps (1) to the care with which the I. Q.'s were determined, and (2) to unusual ability in estimation on the part of the teachers.

TABLE III
Correlation of Binet I. Q. with Teachers' Estimates of Intelligence.

Grade	1st Est.	2nd Est.
8	.70	.75
7	.77	.68
6	.70	.69
5	.66	.68
4	.72	.71
All Grades	.69	.69

The probable error of the above shown coefficients is approximately .04 for all except the last, where it drops to less than half that amount. On the basis of the total showing made in the data it was concluded that the determination of the general intelligence of the subjects had been reliably made, and that it was safe to use the results as a criterion in the remainder of the study.

The next step was to give to the same subjects a group intelligence test consisting of twenty single tests, nine of which were predominantly of the perceptual type, and eleven predominantly of the symbol type.* Before these tests could be given the number of subjects in the group had been reduced, by graduation and other factors, to 222. The raw data for the group tests of these 222 subjects is shown in Table IV. The mental ages given in the table are rectified mental ages. They have been brought up to date by the usual method based upon (1) the difference between the date of the Binet and the date of the other test, and (2) the theory that the I. Q. (relation of chronological and mental age) remains approximately constant.

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* Copies of these tests, and also of the tests used in the lower grade investigation, are filed at Stanford University.

TABLE IV, A
Raw Data for the Nine Perceptual Tests.
Eighth Grade.

	Group A						Group B								
Case	1	2	3	4	5	Total	1	2	3	4	Total	Total	IQ	CA	MA
40	16	8	32	18	20	94	4	10	9	9	32	126	99	15-2	15-0
51	15	9	30	15	8	77	7	9	9	13	38	115	98	17-0	15-8
54	13	11	39	18	9	90	8	8	10	15	41	131	102	14-8	14-10
56	13	11	39	18	7	88	10	5	9	15	39	127	93	15-6	14-4
59	16	11	37	18	20	102	10	10	9	10	39	141	104	14-2	14-8
60	13	7	31	17	6	74	9	7	9	15	40	114	97	16-4	15-10
63	14	9	35	18	7	83	10	10	9	7	36	119	79	17-0	12-9
65	15	11	34	17	14	91	6	9	8	11	34	125	106	14-6	15-4
66	13	8	35	18	15	89	10	7	9	12	38	127	97	13-11	13-5
71	13	10	39	18	16	96	9	7	8	14	38	134	81	15-2	12-4
72	13	12	39	17	14	95	10	9	10	15	44	139	96	15-10	14-3
Seventh Grade															
2	14	6	35	16	12	83	9	8	10	11	38	121	111	14-2	15-8
3	16	13	37	18	17	101	9	10	10	15	44	145	121	13-9	16-7
4	15	9	30	11	16	81	10	8	6	7	31	112	93	15-8	14-7
5	15	12	39	17	17	100	10	10	10	14	44	144	116	14-7	16-10
6	15	9	32	15	18	89	9	10	9	9	37	126	93	17-2	14-10
7	14	10	29	15	9	77	10	8	10	12	40	117	110	14-1	15-5
11	16	9	37	18	13	93	10	9	9	12	40	133	109	14-11	16-5
12	16	11	35	17	13	92	10	10	10	13	43	135	121	14-0	16-11
13	15	12	38	18	12	95	10	10	9	14	43	138	123	13-3	16-3
14	13	11	32	11	16	83	10	9	9	12	40	123	93	16-0	15-0
17	15	11	38	16	16	96	10	10	10	12	42	138	141	14-0	19-9
18	12	9	31	14	8	74	9	6	8	12	35	109	62	15-10	9-10
19	15	12	32	18	20	97	10	10	10	12	42	139	93	15-1	14-0
21	12	12	35	15	17	91	10	10	8	13	41	132	89	15-4	13-7
22	15	11	37	18	14	95	10	9	8	15	42	137	110	13-11	15-4
23	16	9	26	15	13	79	8	8	9	10	35	114	99	14-5	14-3
24	15	10	28	15	11	79	9	10	9	10	38	117	119	14-3	16-11
25	15	7	27	18	16	83	9	10	9	14	42	125	118	12-11	15-2
26	14	10	36	16	18	94	9	9	9	14	41	135	107	15-3	16-5
27	14	9	26	15	10	74	7	9	8	8	32	106	92	14-0	12-10
30	13	11	39	18	12	93	10	10	9	15	44	137	115	14-0	16-1
31	13	10	32	18	15	88	10	8	9	12	39	127	100	13-11	13-10
33	14	10	35	18	20	97	10	10	10	13	43	140	127	14-0	17-9
35	14	9	36	18	11	88	10	10	10	13	43	131	106	14-1	15-0
37	15	9	25	18	11	78	10	8	8	8	34	112	88	15-8	13-8
38	15	7	32	10	9	73	10	8	9	6	33	106	88	14-9	12-11
39	15	10	24	18	12	79	9	8	10	10	37	116	109	14-5	15-10
40	13	9	26	13	11	72	6	8	3	9	26	98	95	13-3	12-8
41	14	7	29	16	14	80	9	9	10	13	41	121	100	15-9	15-9
42	16	8	37	18	17	96	9	10	10	13	42	138	117	14-5	16-10
43	14	7	22	17	11	71	10	9	9	13	41	112	93	14-5	13-4
45	15	12	32	18	13	90	10	10	9	11	40	130	130	13-0	16-10
46	16	9	28	18	13	84	8	10	9	12	39	123	97	14-2	13-8

TABLE IV, A (Continued)

Seventh Grade

	Group A						Group B								
Case	1	2	3	4	5	Total	1	2	3	4	Total	Total	IQ	CA	MA
47	14	7	39	16	9	85	10	9	8	10	37	122	80	14-5	11-5
48	16	8	34	14	12	84	10	10	10	10	40	124	148	12-6	18-5
49	14	10	38	18	16	96	8	7	8	14	37	133	91	13-11	12-8
50	12	11	39	18	12	92	10	8	8	13	39	131	114	12-11	14-9
51	15	8	34	17	13	87	9	9	10	10	38	125	74	16-1	12-1
52	14	12	35	18	14	93	10	8	10	14	42	135	114	13-8	15-7
53	15	12	37	18	17	99	10	5	8	12	35	134	99	14-5	14-3
54	13	10	30	16	20	89	9	8	10	10	37	126	83	14-10	12-4
55	14	7	31	17	17	86	10	6	7	14	37	123	84	14-8	12-4
56	12	10	35	15	7	79	10	6	8	9	33	112	122	12-10	15-7
57	14	11	39	13	14	91	10	7	9	14	40	131	93	14-0	13-0
58	16	12	34	18	17	97	10	10	10	14	44	141	113	13-11	15-8
60	15	9	39	15	20	98	10	10	9	15	44	142	121	13-6	16-3
61	13	9	39	18	16	95	9	10	9	10	39	133	112	14-0	15-10
62	12	9	26	18	10	75	9	9	10	10	38	113	93	13-6	12-6
63	9	8	25	14	13	69	10	3	7	9	29	98	88	14-10	13-0
64	14	9	31	12	13	79	10	7	8	14	39	118	92	14-2	13-0
65	15	10	27	17	14	83	9	10	10	9	38	121	128	13-4	17-2
66	12	10	35	18	18	93	10	7	7	11	35	128	110	13-8	15-1
67	16	12	36	16	17	97	10	9	8	14	41	138	122	11-11	14-5

Sixth Grade

1	14	10	39	15	2	80	5	8	9	9	31	111	98	13-4	13-1
2	15	8	20	17	14	74	6	10	9	14	39	113	81	15-5	12-6
3	12	9	37	18	16	92	9	9	8	9	35	127	99	15-7	15-4
6	14	10	33	18	15	90	10	10	8	8	36	126	102	13-5	13-8
7	11	10	28	16	12	77	9	10	6	9	34	111	85	15-4	13-0
8	16	9	31	17	13	86	8	9	10	9	36	122	86	14-10	12-8
9	13	8	37	15	18	91	9	10	9	14	42	133	94	13-10	13-1
10	16	10	35	18	16	95	10	10	9	14	43	138	140	12-4	17-3
12	10	7	31	12	14	74	8	0	5	14	27	101	74	17-0	12-0
13	16	6	30	13	11	76	8	10	12	13	41	117	101	13-3	13-5
14	16	14	39	18	20	107	9	9	9	15	42	149	94	13-11	13-2
15	11	9	35	18	16	89	10	9	10	10	39	128	88	13-10	12-3
16	15	10	37	13	14	89	10	10	9	10	39	128	107	13-8	14-7
17	16	12	39	18	17	102	9	10	10	15	44	146	98	13-11	13-9
18	14	10	39	18	11	92	10	6	6	15	37	129	91	12-10	11-8
21	14	8	39	18	12	91	9	9	7	13	38	129	102	12-0	12-3
22	16	11	37	18	14	96	9	10	9	8	36	132	120	13-10	16-6
23	13	8	24	16	16	77	9	10	9	9	37	114	107	13-3	14-2
24	15	12	39	17	15	98	10	10	10	13	43	141	143	11-8	16-8
25	14	10	32	17	16	89	10	9	10	13	42	131	135	12-8	17-0
26	12	9	34	18	12	85	10	7	9	9	35	120	79	15-0	11-10
27	12	9	37	18	14	88	7	5	7	12	31	119	72	14-3	10-4
30	16	10	35	11	17	89	10	8	10	13	41	130	105	12-10	13-5
32	12	8	30	16	10	76	8	9	8	7	32	108	98	13-9	13-4
35	14	7	28	18	10	77	9	10	9	11	39	116	123	12-11	15-10
36	15	9	37	14	11	86	9	10	9	15	43	129	134	12-3	16-4
38	15	11	37	18	14	95	9	9	9	13	40	135	108	13-7	14-9
39	13	9	29	14	6	71	10	10	4	10	34	105	91	13-3	12-1

Table IV, A (Continued)

Sixth Grade

	Group A						Group B								
Case	1	2	3	4	5	Total	1	2	3	4	Total	Total	IQ	CA	MA
41	15	11	39	18	11	94	9	9	9	14	41	135	110	14-3	15-8
42	10	11	37	18	17	93	10	8	7	14	39	132	122	13-9	16-8
43	12	9	36	16	16	89	9	8	8	9	34	123	104	12-10	13-4
44	15	10	29	16	9	79	9	9	10	8	36	115	88	14-11	13-2
45	15	10	32	18	10	85	10	8	10	13	41	126	119	13-9	16-4
46	14	7	28	14	13	76	10	8	8	9	35	111	111	12-11	14-5
47	8	8	25	15	11	67	6	8	7	9	30	97	93	13-5	12-7
49	14	10	30	15	12	81	10	9	0	9	28	109	89	13-3	11-10
50	14	8	31	12	15	80	9	8	8	14	39	119	87	14-5	12-6
51	15	12	29	14	10	80	9	8	10	9	36	116	121	12-7	15-2
52	15	7	23	11	17	73	10	9	9	6	34	107	105	13-1	13-8
54	14	8	27	17	18	84	8	9	8	12	37	121	119	13-7	16-2
55	16	8	24	18	14	80	8	9	7	11	35	115	117	12-7	14-7
56	12	8	33	13	11	77	10	4	7	11	32	109	97	11-9	10-8
57	14	7	39	14	13	87	6	9	7	11	33	120	126	13-11	17-6
58	11	7	19	18	17	72	7	8	3	0	18	90	119	12-3	14-6
59	12	6	26	7	12	63	9	10	8	9	36	99	98	12-11	12-5
61	8	7	25	10	12	62	10	5	8	12	35	97	91	13-2	11-11
66	13	9	39	18	14	93	10	7	10	11	38	131	100	12-1	12-1
67	12	9	27	14	8	70	8	9	4	12	33	103	92	13-1	12-0
70	13	9	39	17	10	88	9	8	0	8	25	113	82	14-10	12-5
71	15	13	30	18	18	94	8	9	10	15	42	136	109	14-1	15-4
72	12	12	30	13	20	87	9	9	8	11	37	124	102	12-9	13-1
73	7	7	34	17	10	75	8	6	7	9	30	105	74	15-2	11-3

Fifth Grade

	Group A						Group B								
Case	1	2	3	4	5	Total	1	2	3	4	Total	Total	IQ	CA	MA
1	7	8	30	11	14	70	9	9	8	11	37	107	105	11-10	12-5
2	14	0	29	18	17	78	9	8	9	9	35	113	97	13-3	12-10
3	13	8	28	13	14	76	8	6	5	12	31	107	84	13-5	11-4
5	9	7	22	10	16	64	9	10	8	10	37	101	80	13-4	10-7
6	13	9	25	12	11	70	9	8	9	11	37	107	94	13-2	12-4
7	15	7	26	14	13	75	9	9	9	9	36	111	152	11-3	17-4
8	14	9	29	18	6	76	9	9	8	12	38	114	105	11-7	12-1
9	14	8	30	13	17	82	7	10	10	4	31	113	127	13-1	16-6
10	11	8	31	18	17	85	10	9	10	15	44	129	117	13-7	15-11
11	14	7	28	8	11	68	8	7	7	6	28	96	93	13-10	12-10
15	12	7	28	11	8	66	9	5	9	8	31	87	80	15-1	12-1
16	14	8	27	17	6	72	9	9	7	12	37	104	98	11-10	11-8
17	14	6	30	14	14	78	9	9	6	11	35	113	84	13-3	11-2
18	14	7	27	17	18	83	8	8	7	11	34	117	118	12-1	14-3
19	12	8	28	14	14	76	9	10	8	4	31	107	116	12-7	14-6
20	12	10	22	16	15	75	10	8	10	8	36	111	110	12-6	13-9
21	15	9	27	15	18	84	9	9	9	10	37	121	86	15-3	13-3
22	14	8	32	17	11	82	9	10	8	10	37	119	151	10-9	16-3
23	13	9	32	11	15	80	10	9	9	9	37	117	98	12-9	12-5
24	12	7	30	15	16	80	10	9	10	13	42	121	103	11-9	12-1
25	14	12	39	18	14	97	10	10	9	13	42	139	95	12-2	11-8
26	13	9	27	11	10	70	9	9	7	5	30	100	97	12-6	12-2
27	13	9	31	12	14	79	9	5	6	10	30	109	85	14-2	12-0

TABLE IV, A (Continued)
Fifth Grade (Continued)

	Group A						Group B								
Case	1	2	3	4	5	Total	1	2	3	4	Total	Total	IQ	CA	MA
29	12	10	27	12	18	79	10	7	1	13	31	110	94	12-1	11-5
30	13	8	25	14	15	75	10	9	9	12	40	115	113	12-1	13-7
31	12	9	21	9	11	62	5	9	10	8	32	94	88	14-3	12-6
32	13	9	24	9	12	67	7	10	6	11	34	101	113	11-4	12-10
33	14	7	33	15	7	76	9	5	5	8	27	103	100	11-6	11-7
35	14	8	28	16	15	81	8	9	10	15	42	123	194	12-5	12-11
36	15	8	25	12	9	69	9	6	7	7	29	98	90	12-10	11-7
38	12	10	34	11	11	78	9	10	7	9	35	113	91	12-4	11-3
39	14	9	22	13	10	68	8	9	5	9	31	99	108	12-6	13-6
40	13	9	39	17	13	91	10	8	7	8	33	124	106	11-5	12-1
41	9	8	24	15	14	70	10	8	10	8	36	106	126	11-7	14-6
44	14	9	20	11	16	70	9	7	9	9	34	104	116	11-2	12-11
45	14	9	28	15	12	78	9	9	8	7	33	111	105	12-2	12-8
46	14	7	26	15	14	76	10	9	10	9	38	114	143	10-8	15-3
47	9	9	26	18	14	76	10	7	8	8	33	109	111	11-5	12-8
51	14	9	22	18	0	63	8	8	8	0	24	87	76	13-8	10-5
52	15	7	27	10	11	70	8	9	7	8	32	102	89	13-5	11-11
53	12	7	39	13	13	84	9	10	0	8	27	111	93	13-9	11-10
54	13	7	20	11	9	60	10	10	7	8	35	95	136	11-6	15-8
55	13	9	26	10	1	59	9	8	7	11	35	94	82	12-7	10-4
56	14	8	27	10	11	60	8	5	6	9	28	88	109	11-8	12-8
57	12	8	27	14	17	78	8	8	8	9	33	111	85	13-11	11-9
58	13	7	25	12	14	71	9	9	6	6	30	101	106	10-8	11-3
59	15	8	28	16	20	87	9	10	8	12	39	126	84	13-2	11-2
61	16	8	26	14	13	77	8	8	9	10	35	112	88	11-9	10-3
62	10	8	23	9	12	62	5	10	7	9	31	93	93	11-4	10-6
63	13	6	25	15	11	70	6	10	8	14	38	108	95	10-9	10-3
64	14	9	23	9	15	70	7	10	8	8	33	103	98	11-8	11-5
65	11	7	25	11	0	54	10	6	7	8	31	85	91	11-2	10-1
67	15	9	32	15	11	82	7	8	8	15	38	120	95	11-6	11-0
68	13	10	37	15	12	87	5	7	8	10	30	117	93	11-10	11-0
69	15	6	37	14	12	84	6	7	8	15	36	120	75	13-6	10-1
70	9	7	31	14	0	61	8	8	10	9	35	96	94	11-11	11-2
71	14	9	21	12	5	61	10	10	8	11	39	100	162	11-2	18-0
74	10	8	26	11	4	49	9	8	8	12	37	86	83	12-2	10-1
75	14	9	36	15	9	83	7	8	8	13	36	119	100	11-9	11-9
78	14	8	27	18	17	84	8	8	9	13	38	122	95	11-9	11-2
79	13	7	35	13	7	75	9	8	8	11	36	111	89	12-7	11-2
Fourth Grade															
1	14	6	21	10	13	64	5	8	9	10	32	96	108	11-3	12-2
2	15	7	23	5	0	50	8	7	6	8	29	79	88	11-1	9-9
5	11	7	26	10	14	68	8	10	8	6	32	100	126	11-3	14-0
6	13	8	25	13	11	70	9	10	4	13	36	106	103	11-4	11-8
9	11	8	25	16	14	74	8	6	10	13	37	111	126	10-8	13-4
10	14	7	22	11	18	72	10	9	9	10	38	110	99	11-11	11-9
11	13	9	28	18	16	84	9	10	9	8	36	120	88	11-9	10-4
13	15	11	29	18	16	89	10	10	10	13	43	132	141	12-0	16-10
14	13	9	25	10	12	69	8	10	9	8	35	104	108	12-7	13-8
15	13	8	21	14	11	67	9	9	6	12	36	103	102	11-5	11-7
17	12	8	31	16	12	79	7	6	9	8	30	109	89	11-0	9-9
18	13	11	31	13	17	85	8	10	10	13	41	126	148	9-9	14-4
19	13	9	32	13	14	81	6	9	8	11	34	115	100	10-7	10-11

TABLE IV, A (Continued

Fourth Grade (Continued)

	Group A						Group B								
Case	1	2	3	4	5	Total	1	2	3	4	Total	Total	IQ	CA	MA
20	13	8	21	15	14	71	8	8	5	14	35	106	90	12-10	11-6
21	9	8	21	9	4	51	8	8	3	6	25	76	93	11-7	10-9
22	13	5	28	10	11	67	9	7	7	10	33	100	79	12-7	10-0
23	15	8	25	13	13	74	7	10	8	7	32	106	138	11-0	15-6
25	10	7	19	4	13	53	8	7	0	8	23	76	69	12-11	8-11
27	16	4	17	12	8	57	4	5	2	5	16	73	70	13-0	9-3
28	11	8	25	10	7	61	8	4	1	12	25	86	73	12-3	9-0
29	13	5	23	12	3	56	9	4	2	10	25	81	73	12-3	9-0
30	14	7	30	14	17	82	9	7	8	11	35	117	114	11-3	12-9
31	15	7	19	15	12	68	4	7	10	9	30	98	92	11-10	10-10
32	12	6	18	12	7	55	10	10	8	12	40	95	91	11-7	10-6
33	12	9	30	17	13	81	8	6	8	8	30	111	121	10-6	12-8
35	13	7	25	10	12	67	8	8	8	6	30	97	77	13-5	10-4
38	14	8	24	17	13	76	6	8	9	8	31	107	112	10-2	11-5
40	14	7	25	18	14	78	6	9	8	12	35	113	119	10-4	12-4
46	10	5	18	0	4	37	10	6	6	6	28	65	116	9-7	11-1
47	9	9	25	12	12	67	9	9	8	7	33	100	112	10-1	11-4
48	12	2	23	7	0	44	6	6	2	6	20	64	92	11-5	10-6
49	14	7	24	9	12	66	9	8	4	6	27	93	96	11-2	10-9
51	11	7	24	9	11	62	9	7	9	13	38	100	112	10-4	11-7
52	11	8	27	15	11	72	8	7	7	13	35	107	98	11-5	11-3
54	12	7	26	11	13	69	8	9	7	6	30	99	138	9-11	13-8
55	10	7	28	12	13	70	8	7	9	10	34	104	107	10-8	11-5
57	15	7	37	13	7	74	9	9	7	7	32	111	116	10-0	11-6
58	12	6	19	13	13	63	6	8	7	5	26	89	94	10-9	10-1
59	15	10	21	15	11	72	10	9	8	7	34	106	100	11-0	11-0
60	10	7	27	9	11	64	9	8	6	4	27	91	114	9-7	10-11
61	11	7	28	13	11	70	9	8	5	11	33	103	90	10-5	9-4
62	8	6	22	8	3	47	7	4	6	3	20	67	82	14-1	11-6
64	11	7	21	13	14	66	9	9	8	6	32	98	91	11-9	10-8
65	12	9	29	14	14	78	9	9	9	13	40	118	82	12-1	10-0
66	9	7	19	8	12	55	8	0	6	7	21	76	103	10-2	10-5

TABLE IV, B

Raw Data for the Eleven Symbol Tests.

Eighth Grade

	Group A							Group B									
Case	1	2	3	4	5	6	Total	1	2	3	4	5	Total	Total	IQ	CA	MA
40	8	7	23	25	9	22	94	14	31	10	10	22	87	181	99	15-2	15-0
51	7	6	33	28	10	11	95	11	32	9	17	18	87	182	98	17-0	15-10
54	7	7	27	28	14	21	104	14	30	9	13	21	87	191	102	14-8	14-10
56	7	7	16	22	10	18	80	14	16	7	11	18	66	146	93	15-6	14-4
59	11	8	19	31	13	21	103	15	32	9	15	20	91	194	104	14-2	14-8
60	5	7	14	25	9	14	74	10	22	9	10	15	66	140	97	16-4	15-10
63	6	7	14	21	9	11	68	10	27	9	7	11	64	132	79	17-0	12-9
65	6	9	34	35	15	22	121	10	33	9	19	21	92	213	106	14-6	15-4
66	5	5	16	20	9	15	70	12	22	8	10	12	64	134	97	13-11	13-5
71	8	9	19	23	9	14	82	14	32	10	13	16	85	167	81	15-2	12-4
72	4	8	22	26	15	17	92	12	28	8	15	23	86	178	96	15-10	14-3

TABLE IV, B (Continued)
Seventh Grade

	Group A							Group B									
Case	1	2	3	4	5	6	Total	1	2	3	4	5	Total	Total	IQ	CA	MA
2	9	8	20	26	13	15	91	14	25	8	14	18	79	170	111	14-2	15-8
3	10	9	33	24	16	22	114	14	30	10	10	21	85	199	121	13-9	16-7
4	6	6	21	28	8	14	83	10	25	8	10	17	70	153	93	15-11	14-7
5	13	9	30	38	13	23	126	14	36	10	14	22	96	222	116	14-7	16-10
6	10	7	24	27	10	20	98	13	25	9	11	15	73	171	93	17-2	14-10
7	9	7	19	25	10	22	92	12	24	9	9	21	75	167	110	14-1	15-5
11	5	8	14	29	8	19	83	10	20	9	11	18	68	151	109	14-11	16-5
12	10	7	25	31	11	20	104	14	36	10	13	21	94	198	121	14-0	16-11
13	7	7	27	38	15	22	116	15	33	10	15	23	96	212	123	13-3	16-3
14	6	8	17	24	9	18	82	15	29	9	13	17	83	165	93	16-0	15-0
17	10	8	23	35	14	23	113	12	34	10	17	16	89	202	141	14-0	19-9
18	3	5	9	10	6	9	42	10	17	5	8	9	49	91	62	15-10	9-10
19	8	8	24	30	13	19	102	13	34	9	14	18	88	190	93	15-1	14-0
21	5	7	17	13	11	15	68	11	25	9	13	14	72	140	89	15-4	13-7
22	6	7	19	26	11	23	92	14	31	10	12	18	85	177	110	13-11	15-4
23	9	8	27	26	11	20	101	13	26	10	9	19	77	178	99	14-5	14-3
24	8	8	17	27	11	14	85	10	28	10	13	18	79	164	119	14-3	16-11
25	10	6	23	30	6	19	94	14	29	9	8	11	71	165	118	12-11	15-2
26	10	9	23	21	9	21	93	11	18	7	13	19	68	161	107	15-3	16-5
27	8	9	22	28	6	19	92	10	19	6	10	17	62	154	92	14-0	12-10
30	11	9	22	31	14	21	108	16	32	8	13	20	89	197	115	14-0	16-1
31	2	8	24	33	11	18	96	15	25	9	12	15	76	172	100	13-11	13-10
33	7	8	19	35	9	23	101	15	33	10	13	18	89	190	127	14-0	17-9
35	5	8	12	26	5	17	73	11	15	7	6	9	48	121	106	14-1	15-0
37	5	6	15	22	8	17	73	13	21	9	13	18	74	147	88	15-8	13-8
38	7	6	25	24	9	14	85	9	28	8	13	11	69	154	88	14-9	12-11
39	8	7	21	27	9	22	94	11	21	8	14	18	72	166	109	14-5	15-10
40	6	8	18	27	10	17	86	9	25	8	9	17	68	154	95	13-3	12-8
41	6	8	24	26	10	19	93	11	19	8	7	20	65	158	100	15-9	15-9
42	7	6	29	25	13	15	95	13	28	9	13	22	85	180	117	14-5	16-10
43	6	8	21	24	9	22	90	11	27	7	7	19	71	161	93	14-5	13-4
45	8	8	24	29	11	21	101	13	34	9	10	18	84	185	130	13-3	16-10
46	8	7	15	18	10	14	72	11	12	6	10	21	60	132	97	14-2	13-8
47	6	6	14	19	9	15	69	13	23	9	11	15	71	140	80	14-5	11-5
48	10	9	32	34	15	21	121	16	39	10	12	22	99	220	148	12-6	18-5
49	5	8	21	22	10	17	83	13	33	9	11	20	86	169	91	13-11	12-8
50	9	9	28	31	13	22	112	14	36	10	14	22	96	208	114	12-11	14-9
51	5	7	21	25	9	14	81	10	24	6	12	13	65	146	74	16-1	12-1
52	10	8	22	27	11	21	99	12	22	10	12	15	71	170	114	13-8	15-7
53	7	8	15	23	7	17	77	13	17	8	9	17	64	141	99	14-5	14-3
54	3	7	11	12	6	11	50	7	21	7	10	15	60	110	83	14-10	12-4
55	7	7	23	26	13	13	89	12	24	9	13	18	76	165	84	14-8	12-4
56	6	7	17	24	10	15	79	12	20	8	15	16	71	150	122	12-10	15-7
57	7	8	17	28	12	18	90	10	27	9	17	14	77	167	93	14-0	13-0
58	8	8	26	27	12	22	103	11	32	9	14	22	88	191	113	13-11	15-8
60	8	7	25	31	10	20	101	12	36	8	8	21	85	186	121	13-6	16-3
61	3	8	16	24	11	17	79	11	30	10	15	16	82	161	112	14-0	15-10
62	6	7	24	27	9	15	88	12	28	9	6	22	77	165	93	13-6	12-6
63	6	7	19	25	10	17	84	12	25	8	9	14	68	152	88	14-10	13-0
64	4	8	13	16	10	16	67	9	20	10	12	21	72	139	92	14-2	13-0
65	9	6	27	38	13	21	114	12	34	10	21	14	91	205	128	13-4	17-2
66	6	8	18	25	14	19	90	15	20	9	13	19	76	166	110	13-8	15-1
67	5	8	25	26	14	21	99	9	29	10	15	20	83	182	122	11-11	14-5

TABLE IV, B (Continued)
Sixth Grade

	Group A							Group B									
Case	1	2	3	4	5	6	Total	1	2	3	4	5	Total	Total	IQ	CA	MA
1	6	7	17	20	7	17	74	9	27	7	9	16	68	142	98	13-4	13-1
2	3	7	15	22	8	13	68	8	23	6	9	19	65	133	81	15-5	12-6
3	8	4	22	25	11	15	85	12	27	9	8	19	75	160	99	15-7	15-4
6	8	8	16	32	11	20	95	13	34	10	10	19	86	181	102	13-5	13-8
7	4	3	7	18	5	12	49	9	19	8	7	12	55	104	85	15-4	13-0
8	5	7	17	21	11	19	80	12	21	9	5	12	59	139	86	14-10	12-8
9	6	8	15	16	8	16	69	10	25	5	6	18	64	133	94	13-10	13-1
10	9	8	25	34	14	12	102	11	34	10	14	20	89	191	140	12-4	17-3
12	1	6	17	22	10	17	73	11	16	7	7	15	56	129	74	17-0	12-0
13	3	7	18	15	10	21	74	13	19	9	11	18	70	144	101	13-3	13-5
14	6	9	15	15	11	12	68	12	19	9	12	15	67	135	94	13-11	13-2
15	4	7	20	24	9	11	75	12	31	9	13	19	84	159	88	13-10	12-3
16	7	9	26	38	13	18	111	11	31	7	8	19	76	187	107	13-8	14-7
17	5	7	22	21	11	18	84	12	19	10	13	19	73	157	98	13-11	13-9
18	4	8	16	24	12	13	77	14	27	6	14	18	79	156	91	12-10	11-8
21	6	6	12	27	10	16	77	10	18	9	9	16	62	139	102	12-0	12-3
22	8	9	22	32	14	18	103	11	28	10	10	16	75	178	120	13-10	16-6
23	7	6	12	22	10	15	72	10	23	8	8	16	65	137	107	13-3	14-2
24	8	9	24	30	13	21	105	11	36	10	13	22	92	197	143	11-8	16-8
25	9	8	14	27	11	18	87	14	28	10	11	17	78	165	135	12-8	17-0
26	8	6	9	14	8	14	59	12	23	6	9	11	61	120	79	15-0	11-10
27	3	7	16	19	8	13	66	12	20	8	10	17	67	133	72	14-3	10-4
30	5	9	24	25	10	9	82	10	33	7	15	19	84	166	105	12-10	13-5
32	5	7	14	23	10	12	71	11	28	7	10	19	75	146	98	13-9	13-4
35	10	9	20	27	9	20	95	11	26	10	10	18	75	170	123	12-11	15-10
36	8	7	28	22	14	19	98	10	34	9	15	22	90	188	134	12-3	16-4
38	8	8	23	24	7	19	89	11	26	10	14	18	79	168	108	13-7	14-9
39	4	8	26	25	12	15	90	10	26	9	13	21	79	169	91	13-3	12-1
41	5	8	24	38	13	17	105	14	30	9	18	22	93	198	110	14-3	15-8
42	6	7	20	20	13	18	84	10	29	8	13	20	80	164	122	13-9	16-8
43	7	7	15	21	10	16	76	10	26	10	10	17	73	149	104	12-10	13-4
44	8	5	10	28	8	16	75	11	23	5	9	16	64	139	88	14-11	13-2
45	9	7	18	28	9	17	88	12	27	9	14	22	84	172	119	13-9	16-4
46	8	8	16	28	10	12	82	13	28	8	11	15	75	157	111	12-11	14-5
47	4	7	11	21	8	15	66	9	20	9	7	12	57	123	93	13-5	12-7
49	8	7	15	26	10	17	83	12	24	7	12	15	70	153	89	13-3	11-10
50	5	7	19	17	10	15	73	12	30	9	10	15	76	149	87	14-5	12-6
51	9	8	19	30	10	22	98	11	34	10	5	18	78	176	121	12-7	15-2
52	5	7	10	21	5	10	58	11	20	9	8	12	60	118	105	13-1	13-8
54	7	7	21	27	11	22	95	10	35	9	9	16	79	174	119	13-7	16-2
55	6	6	9	18	9	13	61	10	19	8	10	15	62	123	117	12-7	14-7
56	5	7	17	22	8	8	67	11	22	6	11	17	67	134	97	11-9	10-8
57	9	8	18	31	12	21	99	11	23	10	13	23	80	179	126	13-11	17-6
58	9	5	25	23	10	17	89	11	30	7	10	11	69	158	119	12-3	14-6
59	6	5	8	18	4	14	55	10	17	7	9	12	55	110	96	12-11	12-5
61	6	6	12	25	10	17	76	8	20	10	12	16	66	142	91	13-2	11-11
66	4	6	13	24	11	22	80	10	23	6	13	17	69	149	100	12-1	12-1
67	5	5	8	19	7	11	55	8	17	6	7	8	46	101	92	13-1	12-0
70	4	7	10	0	11	10	42	11	20	5	9	13	58	100	82	14-10	12-5
71	6	9	17	18	11	21	82	11	22	9	9	21	72	154	109	14-1	15-4
72	4	6	14	12	9	17	62	10	22	7	6	17	62	124	102	12-9	13-1
73	2	5	13	19	8	11	58	11	26	6	11	12	66	124	74	15-2	11-3

TABLE IV, B (Continued)
Fifth Grade

	Group A							Group B									
Case	1	2	3	4	5	6	Total	1	2	3	4	5	Total	Total	IQ	CA	MA
1	6	8	13	20	8	16	71	11	22	7	12	3	55	126	105	11-10	12-5
2	7	6	14	22	9	10	68	11	27	6	8	15	67	135	97	13-3	12-10
3	3	3	11	20	5	8	50	5	19	5	8	12	49	99	84	13-5	11-4
5	6	6	14	20	8	10	64	9	21	6	9	10	55	119	80	13-4	10-7
6	7	8	13	20	7	15	70	10	19	9	10	12	60	130	94	13-2	12-4
7	11	7	20	28	14	22	102	10	31	10	9	12	72	174	152	11-3	17-4
8	7	7	18	22	10	17	81	10	18	7	9	18	62	143	105	11-7	12-1
9	7	7	20	31	12	14	91	6	26	8	16	19	75	166	127	13-1	16-6
10	7	9	25	31	13	21	106	10	39	8	11	22	90	196	117	13-7	15-11
11	4	4	6	16	7	11	48	9	18	7	9	12	55	103	93	13-10	12-10
15	8	5	12	14	9	5	53	9	16	3	7	12	47	100	80	15-1	12-1
16	5	6	12	22	8	15	68	12	21	8	11	13	65	133	98	11-10	11-8
17	5	6	13	17	9	12	62	8	23	7	13	17	68	130	84	13-3	11-2
18	3	7	16	23	8	12	69	12	25	7	11	19	74	143	118	12-1	14-3
19	12	8	21	28	11	21	101	12	32	10	15	21	90	191	116	12-7	14-6
20	8	7	18	27	11	22	93	9	33	9	15	20	86	179	110	12-6	13-9
21	4	8	16	22	10	11	71	8	26	9	10	16	69	140	86	15-3	13-3
22	7	7	24	38	10	19	105	12	34	10	16	17	89	194	151	10-9	16-3
23	4	8	16	17	10	15	70	10	22	8	9	15	64	134	98	12-9	12-5
24	7	7	14	25	11	14	78	11	23	9	10	15	68	146	103	11-9	12-1
25	8	8	15	24	9	20	84	9	27	9	9	14	68	152	95	12-2	11-8
26	4	7	9	14	9	9	52	10	18	5	9	13	55	107	97	12-6	12-2
27	3	7	13	21	10	15	69	9	18	5	9	11	52	121	85	14-2	12-0
29	5	7	18	15	7	12	64	9	16	8	6	9	48	112	94	12-1	11-5
30	7	8	24	30	10	20	99	11	28	9	13	12	73	172	113	12-1	13-7
31	6	2	15	6	5	14	48	10	17	5	8	8	48	96	88	14-3	12-6
32	7	7	25	27	12	18	96	12	25	10	8	18	73	169	113	11-4	12-10
33	4	7	9	19	8	12	59	10	17	9	7	12	55	114	100	11-6	11-7
35	5	6	18	26	11	18	86	12	24	7	11	16	70	156	104	12-5	12-11
36	3	6	14	25	9	12	69	9	25	7	13	15	69	138	90	12-10	11-7
38	7	7	12	14	9	10	59	11	23	6	9	11	60	119	91	12-4	11-3
39	5	4	11	16	8	12	56	8	27	7	9	16	67	123	108	12-6	13-6
40	7	7	13	21	8	17	73	10	25	8	12	15	70	143	106	11-5	12-1
41	8	6	12	25	10	21	82	7	29	9	8	15	68	150	126	11-7	14-6
44	4	7	10	17	8	17	63	7	18	7	10	16	58	121	116	11-2	12-11
45	4	7	13	24	7	18	73	8	23	8	11	17	67	140	105	12-2	12-8
46	6	8	14	23	12	18	81	12	26	8	13	16	75	156	143	10-8	15-3
47	4	7	18	27	9	15	80	9	22	10	8	14	63	143	111	11-5	12-8
51	7	6	10	18	3	6	50	8	14	3	9	12	46	96	76	13-8	10-5
52	5	5	17	20	9	2	58	9	19	6	6	12	52	110	89	13-5	11-11
53	8	3	4	15	9	13	52	8	19	4	8	9	48	100	93	12-9	11-10
54	9	6	20	23	11	19	88	11	24	9	11	19	74	162	136	11-6	15-8
55	4	6	14	14	8	6	52	7	17	5	11	18	58	110	82	12-7	10-4
56	8	5	21	14	7	13	68	12	25	5	7	18	67	135	109	11-8	12-8
57	6	5	3	11	5	8	38	6	18	4	8	11	47	85	85	13-11	11-9
58	6	6	15	26	9	15	77	11	27	8	8	16	70	147	106	10-8	11-3
59	3	4	5	7	4	5	28	8	14	3	3	9	37	65	84	13-2	11-2
61	4	5	11	13	6	13	52	9	16	5	7	12	49	101	88	11-9	10-4
62	3	5	10	13	6	10	47	1	13	3	8	13	38	85	93	11-4	10-6
63	4	6	15	11	8	14	58	8	18	1	11	13	51	109	95	10-9	10-3
64	6	4	14	21	9	17	71	6	19	6	11	18	60	131	98	11-8	11-5
65	3	4	5	13	5	4	35	4	14	5	8	9	40	74	91	11-2	10-1
67	4	6	15	0	6	14	45	10	11	4	0	17	42	87	95	11-6	11-0
68	5	7	10	14	7	1	44	10	10	6	11	15	52	96	93	11-10	11-0
69	5	5	12	10	8	13	53	6	17	6	10	13	52	105	75	13-6	10-1

TABLE IV, B (Continued)
Fifth Grade (Continued)

	Group A							Group B									
Case	1	2	3	4	5	6	Total	1	2	3	4	5	Total	Total	IQ	CA	MA
70	5	5	10	5	6	9	40	8	14	5	8	12	47	87	94	11-11	11-2
71	6	6	26	29	9	20	96	9	29	9	10	14	71	167	162	11-2	18-0
74	6	3	8	9	5	13	44	9	17	5	8	12	51	95	83	12-2	10-1
75	4	5	10	16	5	13	53	11	13	4	6	9	43	96	100	11-9	11-9
78	3	3	5	4	3	5	23	8	14	2	4	11	39	62	95	11-9	11-2
79	2	4	3	17	11	16	53	9	14	5	6	17	51	104	89	12-7	11-2
Fourth Grade																	
1	5	4	2	14	4	8	37	10	18	4	6	9	47	84	108	11-3	12-1
2	6	5	9	18	6	5	49	5	20	4	8	11	48	97	88	11-1	9-10
5	5	8	10	18	6	8	55	9	30	10	10	15	74	129	126	11-3	13-11
6	4	4	10	20	5	13	56	8	18	4	6	11	47	103	103	11-4	11-8
9	4	7	15	19	8	15	68	8	19	7	10	16	60	128	126	10-8	13-3
10	4	5	11	14	8	11	53	7	20	5	12	17	61	114	99	11-11	11-9
11	2	4	9	10	2	14	41	5	15	4	8	14	46	87	88	11-9	10-5
13	8	8	21	29	9	19	94	8	24	7	15	22	76	170	141	12-0	16-8
14	4	5	10	27	9	12	67	9	18	8	10	14	59	126	108	12-7	13-7
15	5	5	10	17	7	14	58	6	20	6	8	17	57	115	102	11-5	11-7
17	6	6	8	19	7	15	61	9	21	9	8	15	62	123	89	11-0	9-10
18	7	8	25	30	13	21	104	10	28	10	7	19	74	178	148	9-9	14-1
19	6	7	16	18	9	13	69	9	21	10	11	18	69	138	100	10-7	10-7
20	6	4	9	19	6	14	58	9	13	4	8	14	48	106	90	12-10	11-7
21	6	4	4	19	4	13	50	8	17	6	9	10	50	100	93	11-7	10-10
22	4	6	9	4	6	4	33	7	16	3	9	18	53	86	79	12-7	10-1
23	5	6	17	22	7	16	73	8	30	9	10	16	73	146	138	11-0	15-4
25	4	3	10	19	4	1	41	5	6	3	11	13	38	79	69	12-11	9-1
27	3	6	8	17	8	9	51	5	16	5	8	10	44	95	70	13-0	9-5
28	0	2	12	10	7	6	37	7	16	4	7	9	43	80	73	12-3	9-2
29	0	2	3	0	2	5	12	7	13	2	2	4	28	40	73	12-3	9-2
30	5	5	8	13	5	10	46	8	16	4	7	12	47	93	114	11-3	12-8
31	4	6	11	13	7	14	55	8	16	3	8	9	44	99	92	11-10	10-11
32	4	5	9	13	6	14	51	8	20	5	5	10	48	99	91	11-7	10-7
33	6	5	11	17	6	13	58	9	14	5	10	14	52	110	121	10-6	12-7
35	3	6	6	17	6	15	53	8	16	7	6	12	49	102	77	13-5	10-6
38	2	8	15	18	9	11	63	8	23	7	14	20	72	135	112	10-2	11-4
40	7	7	17	15	11	12	69	9	18	8	15	13	63	132	119	10-4	12-2
46	6	3	7	14	6	5	41	8	18	4	5	10	45	86	116	9-7	11-0
47	4	7	8	21	8	10	58	8	22	7	8	16	61	119	112	10-1	11-3
48	3	5	13	11	7	8	47	6	15	5	7	12	45	92	92	11-5	10-7
49	4	5	13	16	6	11	55	8	19	5	8	14	54	109	96	11-2	10-9
51	2	5	5	12	3	8	35	8	19	1	1	9	38	73	112	10-4	11-6
52	6	5	12	14	8	4	49	0	16	7	11	15	49	98	98	11-5	11-3
54	1	7	18	25	12	19	82	9	24	9	11	18	71	153	139	9-11	13-6
55	4	3	6	14	4	9	40	7	19	3	5	10	44	84	107	10-8	11-4
57	6	8	16	29	9	16	84	11	24	8	8	12	63	147	116	10-0	11-5
58	3	4	8	12	6	13	46	6	18	3	6	11	44	90	94	10-9	10-2
59	4	5	10	17	6	16	58	9	19	6	10	13	57	115	100	11-0	11-0
60	3	6	12	23	6	11	61	7	22	7	7	16	59	120	114	9-7	10-10
61	4	4	10	8	3	8	37	7	17	2	8	5	39	76	90	10-5	9-5
62	2	4	4	11	5	10	36	8	14	5	3	8	38	74	82	14-1	11-8
64	2	4	6	1	5	11	29	9	17	2	8	9	45	74	91	11-9	10-9
65	4	5	3	19	10	10	51	7	17	5	7	12	48	99	82	12-1	10-2
66	1	3	7	16	5	10	42	8	16	5	6	9	44	86	103	10-2	10-5

The first evidence drawn from these data in favor of the theory of levels in intentionally controlled intelligence was found in certain correlations made between the results of the individual and the combined group tests with Binet mental age. A table of these correlations is given below.

Table V

Correlation Coefficients of the Individual and Combined Group Tests with Binet Mental Age.

I.	Perceptual Tests.		II.	Symbol Tests.	
I.	Picture Completion	.42	I.	Arithmetical Reasoning	.63
II.	Series Completion	.46	II.	Written Directions	.58
III.	Comparison	.40	III.	Information	.68
IV.	Symbol Digit	.45	IV.	Synonym-Antonym	.65
V.	Form Combination	.34	V.	Practical Judgment	.65
VI.	Copying Designs	.30	VI.	Analogies	.68
VII.	Pictorial Sequence	.43	VII.	Arithmetical Fundamentals	.59
VIII.	Pictorial Identities	.46	VIII.	Vocabulary	.75
IX.	Recognitive Memory	.29	IX.	Sentence Completion	.68
			X.	Mixed up Sentences	.53
			XI.	Logical Selection	.60
	Total Perceptual	.60		Total Symbol	.80

The tests featured in the foregoing table are those used by the National Research Council in their preliminary trials for the standardization of an elementary school group test. The writer is fully aware that it is psychologically impossible to make an absolute classification of tests as "perceptual" tests and "symbol" tests. Each test is of both types to a certain degree. But it is possible to classify the tests as predominantly of one type or the other, which is all that is necessary to bring out the point in question. Assuming that this is so, the results given in the table show a decided tendency in favor of the theory being tested. The tests in which perceptual elements predominate do not correlate as highly in any case with Binet mental age as do the tests in which symbol elements predominate. The perceptual tests as a battery correlate only .60, while the symbol tests as a battery correlate .80.

The majority of the individual symbol tests taken singly correlate higher with Binet mental age than does the whole battery of perceptual tests. The vocabulary test alone, perhaps the most abstract of all, shows a coefficient which is 15 points above the whole perceptual battery. These differences cannot reasonably be ascribed to mere differences in the amount of standardization which the given tests have had. They have had at least approximately equal standardization. Nor can the differences reasonably be ascribed to differences in reliability of the individual tests, although if time and other conditions had permitted the computation of reliability coefficients would have been a valuable addition to the evidence. The differences shown in the table are, however, so large that it seems a reasonable assumption that they are due, at least in part, to the fact that the two types of tests tap different levels of intelligence, and that on one of these levels, the perceptual, high and low intelligence are closer together in achievement than on the other, and therefore are not so well differentiated by tests which tap only that level.

The next step was that of making a more definite contrast between the achievement of high and low intelligence in the perceptual tests and in the symbol tests. The cases were first distributed as to chronological age and I. Q. as shown in Table VI.

After the cases had been distributed as to chronological age and I. Q., as shown in Table VI, a contrast was made as shown in Table VII. Middle I. Q.'s—those between 92 and 107 inclusive—were dropped; and the achievement of I. Q. below 92 was contrasted with the achievement of I. Q. above 107. The limits of the central group (a span of 15 points from 92 to 107) were chosen rather arbitrarily (1) because seven groups arranged in intervals of 15 points of I. Q. fit very well with the seven point scale upon which teachers' judgments of intelligence were made, and (2) because by actual attempts at distribution, groups based upon intervals of 20 points proved to be too wide, while those based upon intervals of 10 points were too narrow. The contrast was made separately for the perceptual tests as a group, and for the symbol tests as another group. That is, the total scores of the low I. Q.'s in the perceptual tests were ranked and the median score found. The same was done for the scores of the high I. Q.'s in the same tests. Then the median score for low I. Q. was divided by the median score for high I. Q. Thus there was developed a ratio (or index) of the relative success of

Table VI
Chronological Age and Binet I. Q.

10		
No.	Yrs.	I.Q.
Fourth Grade		
9	10-8	126
19	10-7	100
33	10-6	121
38	10-2	112
40	10-4	119
47	10-1	112
51	10-4	112
55	10-8	107
57	10-0	116
58	10-9	94
61	10-5	90
66	10-2	103
Fifth Grade		
22	10-9	151
46	10-8	143
63	10-9	95

11		
No.	Yrs.	I.Q.
Fourth Grade		
1	11-3	108
2	11-1	88
5	11-3	126
6	11-4	103
10	11-11	99
11	11-9	88
15	11-5	102
17	11-0	89
21	11-7	93
23	11-0	138
30	11-3	114
31	11-10	92
32	11-7	91
48	11-5	92
49	11-2	96
52	11-5	98
59	11-0	100
64	11-9	91
Fifth Grade		
1	11-10	105
7	11-3	152
8	11-7	105
16	11-10	98
24	11-9	103
32	11-4	113
33	11-6	100
40	11-5	106
41	11-7	126
44	11-2	116
47	11-5	111
54	11-6	136
56	11-8	109
61	11-9	88
62	11-4	93
64	11-8	98
65	11-2	91
67	11-6	95
68	11-10	93
70	11-11	94
71	11-2	162
75	11-9	100
78	11-9	95
Sixth Grade		
24	11-8	143
56	11-9	97
Seventh Grade		
67	11-11	122

12		
No.	Yrs.	I.Q.
Fourth Grade		
13	12-0	141
14	12-7	108
20	12-10	90
22	12-7	79
25	12-11	69
28	12-3	73
29	12-3	73
65	12-1	82
Fifth Grade		
18	12-1	118
19	12-7	116
20	12-6	110
23	12-9	98
25	12-2	95
26	12-6	97
29	12-1	94
30	12-1	113
35	12-5	104
36	12-10	90
38	12-4	91
39	12-6	108
45	12-2	105
53	12-9	93
55	12-7	82
74	12-2	83
79	12-7	89
Sixth Grade		
10	12-4	140
18	12-10	91
21	12-0	102
25	12-8	135
30	12-10	105
35	12-11	123
36	12-3	134
43	12-10	104
46	12-11	111
51	12-7	121
55	12-7	117
58	12-3	119
59	12-11	96
66	12-1	100
72	12-9	102
Seventh Grade		
25	12-11	118
48	12-6	148
50	12-11	114
56	12-10	122

13		
No.	Yrs.	I.Q.
Fourth Grade		
27	13-0	70
35	13-5	77
Fifth Grade		
2	13-3	97
3	13-5	84
5	13-4	80
6	13-2	94
9	13-1	127
10	13-7	117
11	13-10	93
17	13-3	84
51	13-8	76
52	13-5	89
57	13-11	85
59	13-2	84
69	13-6	75
Sixth Grade		
1	13-4	98
6	13-5	102
9	13-10	94
13	13-3	101
14	13-11	94
15	13-10	88
16	13-8	107
17	13-11	98
22	13-10	120
23	13-3	107
32	13-9	98
38	13-7	108
39	13-3	91
42	13-9	122
45	13-9	119
47	13-5	93
49	13-3	89
52	13-1	105
54	13-7	119
57	13-11	126
61	13-2	91
67	13-1	92
Seventh Grade		
3	13-9	121
13	13-3	123
22	13-11	110
31	13-11	100
40	13-3	95
45	13-3	130
49	13-11	91
52	13-8	114
58	13-11	113
60	13-6	121
13 yrs. (contd.)		
62	13-6	93
65	13-4	128
66	13-8	110
Eighth Grade		
66	13-11	97

14		
No.	Yrs.	I.Q.
Fourth Grade		
62	14-1	82
Fifth Grade		
27	14-2	85
31	14-3	88
Sixth Grade		
8	14-10	86
27	14-3	72
41	14-3	110
44	14-11	88
50	14-5	87
70	14-10	82
71	14-1	109
Seventh Grade		
2	14-2	111
5	14-7	116
7	14-1	110
11	14-11	109
12	14-0	112
17	14-0	141
23	14-5	99
24	14-3	119
27	14-0	92
30	14-0	115
33	14-0	127
35	14-1	106
38	14-9	88
39	14-5	109
42	14-5	117
43	14-5	93
46	14-2	97
47	14-5	80
53	14-5	99
54	14-10	83
55	14-8	84
57	14-0	93
61	14-0	112
63	14-10	88
64	14-2	92
Eighth Grade		
54	14-8	102
59	14-2	104
65	14-6	106

the two groups of pupils in the perceptual tests. The same process carried through for the symbol tests provided an index of the relative success of low and high I. Q. in those tests. Then the two indices were compared. Theoretically, if the achievement of low and high I. Q. is nearer together in the perceptual tests than in the symbol tests (as would naturally be the case if the theory of the levels is true), then the index as obtained above for the perceptual tests would be expected to be smaller than that obtained for the symbol tests. A sample of how such an index is obtained is given in Table VII, and a combined table of a number of such indices is shown in Table VIII.

TABLE VII

Contrast of Achievement of Low and High I. Q. in Perceptual and Symbol Tests.

Chronological Ages 10 and 11

		Perceptual Tests				Symbol Tests			
	Low I. Q.					Low I. Q.			
Case	I.Q.	Score	Scores Ranked	Median	Index	Score	Scores Ranked	Median	Index
4-2	88	79	79			97	74		
4-11	88	120	85			87	74		
4-17	89	109	95			123	76		
4-32	91	95	98			99	87		
				100.5				92	
4-61	90	103	103			76	97		
4-64	91	98	109			74	99		
5-61	88	112	112			101	101		
5-65	91	85	120			74	123		
					.930				.636
	High I. Q.					High I. Q.			
4-1	108	96	95			84	73		
4-5	126	100	96			129	84		
4-9	126	111	100			128	93		
4-23	138	106	100			146	110		
4-30	114	117	100			93	119		
4-33	121	111	100			110	121		
4-38	112	107	101			135	128		
4-40	119	113	104			132	129		
4-47	112	100	106			119	132		
4-51	112	100	106			73	135		
4-57	116	111	107			147	143		
				108				144.5	
5-7	152	111	109			174	146		
5-22	151	119	111			194	147		
5-32	113	101	111			169	150		
5-41	126	106	111			150	156		
5-44	116	104	111			121	162		
5-46	143	114	113			156	167		
5-47	111	109	114			143	169		
5-54	136	95	117			162	174		
5-71	162	100	119			167	182		
6-24	143	141	138			197	194		
7-67	122	138	141			182	197		

Table VIII

Contrast of Achievement of Low and High I. Q. in Perceptual and Smybol Tests

	Perceptual Tests		Symbol Tests	
	Median	Index	Median	Index
	Chronological Ages 10 and 11			
Low I. Q.	100.5	.930	92.0	.636
High I. Q.	108.0		144.5	
	Chronological Ages 11 and 12			
Low I. Q.	98.0	.875	99.0	.60
High I. Q.	112.0		165.0	
	Chronological Ages 12 and 13			
Low I. Q.	103.5	.821	104.5	.60
High I. Q.	126.0		174.0	
	Chronological Ages 13 and 14			
Low I. Q.	111.0	.834	121.0	.679
High I. Q.	133.0		178.0	

It is clear from the above table that in this study the ratio (index) of achievement of low and high I. Q. is nearer to unity in every case for the perceptual tests than for the symbol tests. This is what would be expected if low and high I. Q. are nearer together in achievement on the perceptual than on the symbol level.

This study therefore consists in:

(1) Quantitative determination of the intelligence of a given group.

(2) Verifying the result by means of teachers' judgments.

(3) Testing the same group by means of (a) a number of tests which are primarily perceptual, and (b) a number of tests which are primarily symbolic.

(4) Comparison of perceptual-test results, and symbol-test results, on the basis of the criterion.

This comparison is made (a) through correlation and (b) through the computation of an index denoting per cent of capacity.

By this process it is found (1) that symbol tests surpass perceptual tests in power of discrimination of degrees of intelligence, and (2) that achievement of high and low intelligence is much closer together in perceptual than in symbol material.

The conclusion is made that the study offers evidence in favor of the theory of intelligence levels based upon an analysis of qualitative differences in *judgment* regarded as a mental "common factor."

2. In lower school grades.

This study is of the same form as the other one except that the validity of the Binet mental ages and intelligence quotients is assumed without the checking by teachers' estimates of intelligence. This assumption was felt to be justified because the whole procedure of determining the Binet results was the same as that used in the first study, and it seems safe to believe that the same validity is present.

The value of a second study lies in the confirmatory evidence which it furnishes. It would be expected that the same results as to correlations and indices of relationship between the achievement of low and high I. Q. could be looked for, but with the additional feature that the contrasts based upon differences in achievement in perceptual and in symbol tests would be expected to be less pronounced as a whole in the lower than in upper grades. This is so because if the theory of the levels is true, children of all grades of endowment will differ less in early years before the power of abstraction in any of them has had the chance for development, and consequent differentiation, which comes in later years. The following data will show how this theory works out. Table I gives Binet data (to be used as before as criterion) on 135 lower grade cases.

TABLE I

Original Data: Abbreviated Binet in Lower Grades.

Case	Born	Tested	M.A.	I.Q.
		Second Grade		
1	7/22/12	1/19/20	7- 6	100
2	11/19/12	1/19/20	7- 9	108
3	5/19/03	1/14/20	6- 6	98
4	12/ 9/11	1/16/20	7- 0	87
5	6/ 6/11	1/14/20	9- 1	106
6	10/24/12	1/14/20	7- 3	100
7	7/17/12	1/16/20	7- 9	103
8	12/23/11	1/13/20	8- 3	102
9	4/20/12	1/13/20	7- 9	100
10	6/20/12	1/12/20	7- 6	99
11	2/22/12	1/12/20	6- 9	85
12	1/12/11	1/16/20	6- 3	69

TABLE I (Continued)

Case	Born	Tested	M.A.	I.Q.
		Second Grade (Continued)		
13	3/30/13	2/ 2/20	7- 9	113
14	5/ 3/12	1/16/20	7- 9	100
15	1/21/12	1/14/20	6- 9	85
16	12/ 6/12	1/14/20	7- 3	102
17	1/ 8/12	1/14/20	7- 9	96
18	7/26/12	1/16/20	7- 6	100
19	8/23/12	1/16/20	8- 9	117
20	8/11/11	1/21/20	9- 6	112
21	8/24/12	1/19/20	8- 3	111
22	1/31/10	1/21/20	8- 9	88
23	10/27/11	1/21/20	8- 0	98
24	2/28/12	1/22/20	8- 6	107
25	1/11/13	1/22/20	9- 0	128
26	8/ 1/11	1/22/20	9- 0	106
27	12/10/12	1/ 4/20	8- 6	120
28	5/26/12	1/20/20	8- 3	107
29	6/24/12	1/23/20	6- 3	82
30	7/14/12	1/22/20	8- 6	113
31	1/29/13	1/23/20	9- 0	127
32	4/ 6/11	1/30/20	8- 0	91
33	7/15/11	1/23/20	8- 3	97
34	10/13/11	1/23/20	7- 3	87
35	2/20/12	1/22/20	7- 9	98
36	5/10/11	1/22/20	9- 1	105
37	6/ 7/11	1/22/20	9- 1	105
38	5/ 9/11	1/22/20	9- 0	105
39	5/ 1/11	1/22/20	8- 9	100
40	8/ 8/10	1/22/20	7- 3	77
41	6/ 8/10	1/22/20	8- 1	83
42	3/24/12	1/22/20	8-10	112
43	4/ 2/11	1/22/20	9- 0	102
44	3/ 2/12	1/22/20	9- 4	117
45	5/ 9/12	2/ 2/20	9- 0	116
46	2/21/12	1/22/20	8- 0	101
47	1/30/12	2/ 2/20	8- 3	103
48	10/ 3/11	1/16/20	8-10	107
49	9/23/11	1/ 4/20	8- 0	96
50	7/12/12	1/22/20	8- 3	109
51	9/27/11	1/22/20	8- 3	99
52	2/18/12	1/22/20	7- 3	92
53	5/29/12	1/30/20	8- 0	105
		Third Grade		
54	12/28/10	1/19/20	8- 6	94
55	8/ 1/11	1/14/20	11- 4.5	135
56	6/ 7/11	1/16/20	9- 9	113
57	3/26/11	1/15/20	9- 0	102
58	8/28/11	1/20/20	10- 4	122
59	12/13/11	1/16/20	9- 0	111
60	5/10/12	1/20/20	8- 3	107
61	3/28/11	1/14/20	11- 4	128
62	10/16/10	1/16/20	10- 5	112
63	10/29/11	1/14/20	7- 3	87
64	11/ 1/11	1/20/20	8- 3	101
65	9/10/10	1/20/20	11- 3	120

TABLE I (Continued)

Case	Born	Tested	M.A.	I.Q.
		Third Grade (Continued)		
66	4/28/11	1/20/20	7- 9	88
67	12/19/11	1/20/20	9- 7	119
68	4/ 6/11	1/16/20	8- 9	100
69	1/27/10	1/16/20	9- 4	93
70	8/30/11	1/19/20	9- 0	107
71	11/ 1/11	1/20/20	8- 9	106
72	2/25/11	1/19/20	8- 9	99
73	2/25/11	1/20/20	12- 9.5	143
74	5/23/12	1/19/20	11- 0.5	144
75	7/23/12	1/19/20	9- 6	126
76	4/ 1/10	1/16/20	10- 1	102
77	2/16/12	1/20/20	9- 0	113
78	12/12/11	1/14/20	6- 9	83
79	2/ 3/11	1/16/20	9- 1	102
80	7/ 3/10	1/16/20	10- 2	107
81	2/ 4/11	1/19/20	10- 4	116
82	7/21/11	1/16/20	9- 3	109
83	9/26/10	1/13/20	8- 6	91
84	3/24/10	1/19/20	8- 3	84
85	7/16/12	1/19/20	10- 9	143
86	11/10/10	1/15/20	9- 4	102
87	9/19/10	1/16/20	9- 6	102
88	8/30/10	1/20/20	10- 0	106
89	7/29/11	1/15/20	8- 9	103
90	7/25/10	1/12/20	10- 9	113
91	12/ 8/08	1/14/20	12- 5.5	112
92	7/16/10	1/15/20	10- 1	106
93	7/ 1/10	1/13/20	9-11	104
94	10/ 2/10	1/15/20	9- 3	100
95	11/24/08	1/13/20	9-11	88
96	4/13/10	1/15/20	11-10.5	122
97	10/30/09	1/15/20	9- 7	93
98	12/ 4/08	1/13/20	10-11	98
99	3/16/10	1/13/20	9- 5	95
100	1/30/10	1/14/20	10- 5	105
101	2/22/09	1/12/20	10- 9	99
102	9/19/10	1/12/20	9- 0	96
103	4/14/10	1/15/20	8- 6	87
104	3/20/11	1/14/20	11- 4.5	129
105	6/28/09	1/13/20	9- 6	90
106	11/27/09	1/13/20	8- 6	83
107	2/ 4/11	1/13/20	11- 6	129
108	5/19/10	1/13/20	10- 9	111
109	12/28/09	1/13/20	10- 6	105
110	3/10/09	1/14/20	10- 8	98
111	11/12/10	1/14/20	10- 9	117
112	11/20/10	1/13/20	9- 7	103
113	6/12/10	1/15/20	10- 4	107
114	7/29/10	1/14/20	10- 2	106
115	8/17/10	1/14/20	9- 8	103
116	3/ 2/11	1/13/20	10- 8	120
117	5/ 5/10	1/14/20	10- 1	104
118	11/19/09	1/19/20	9- 7	94

Table I (Continued)
Fourth Grade

Case	Born	Tested	M. A.	I. Q.
119	8/14/10	1/28/20	10- 9.5	115
120	1/ 2/10	2/ 2/20	11- 0	109
121	9/12/08	11/20/19	10- 8	95
122	5/28/08	11/19/19	10- 2	89
123	5/27/08	11/21/19	9- 4	81
124	7/ 6/08	2/ 2/20	10- 5	90
125	11/10/10	1/27/20	14- 5	155
126	12/28/08	2/ 2/20	10- 1	91
127	4/ 1/09	1/28/20	10- 8	98
128	11/22/09	1/27/20	14- 3.5	140
129	11/10/08	1/27/20	9-11	88
130	8/11/07	11/19/19	9- 0	73
131	6/ 6/11	1/28/20	10- 8	123
132	12/15/08	1/26/20	9- 3	83
133	7/26/09	2/ 3/20	11-20	113
134	10/18/09	1/26/20	9-11	97
135	4/15/10	2/ 2/20	10- 5	106

After the Binet data appearing in Table I had been obtained, there was given, as before, a group test consisting of single tests, part of which were primarily perceptual and part symbol. The perceptual tests were (1) symbol digit, (2) picture completion, (3) maze, (4) pictorial sequence, and (5) pictorial identities. These were simply different standardized forms of the same type of tests used in the first study, except for the familiar maze test which does not need description. The symbol tests were (1) practical judgment, (2) opposites, (3) vocabulary.

Of the 135 cases for which Binet data are given, 134 took the tests just listed, except that because of an epidemic it was possible to give the vocabulary test to but 111 cases. Raw data for these cases appear in Table II.

Table II

Raw Data for Five Perceptual and Three Symbol Tests.
Second Grade

	Perceptual Tests						Symbol Tests			
Case	1	2	3	4	5	Total	6	7	8	Total
1	6	11	0	1	1	19	4	4		
2	5	10	4	6	6	31	6	0	6	12
3	5	7	3	4	1	20	6	6	3	15
4	7	9	6	3	9	34	5	8	10	23
5	8	10	8	7	7	40	7	6	3	16
6	3	8	5	4	2	22	0	0		
7	0	11	7	4	2	24	4	5	10	19
8	7	11	6	6	5	35	2	0		
9	4	8	1	0	1	14	6	3	8	17
10	6	8	1	0	2	17	0	0	0	0
11	2	3	0	1	1	7	0	0	0	0

Table II (Continued)

Second Grade

	Perceptual Tests						Symbol Tests			
Case	1	2	3	4	5	Total	6	7	8	Total
12	5	8	2	1	2	18	0	6	2	8
13	5	9	5	2	1	22	4	5	7	16
14	6	2	3	4	1	16	0	4	6	10
15	6	6	0	6	4	22	0	0		
16	7	11	0	5	1	24	5	6		
17	6	4	7	6	2	25	3	6	8	17
18	7	7	0	6	1	21	0	0	5	5
19	8	10	8	5	9	40	5	5	9	19
20	7	10	5	7	3	32	10	5	8	23
21	7	9	5	6	7	34	8	7	8	23
22	7	6	4	4	1	22	6	4	0	10
23	8	8	5	2	1	24	5	6	12	23
24	6	11	7	4	6	34	10	4	9	23
25	6	9	6	6	7	34	8	9	9	26
26	6	9	8	4	6	33	5	5	2	12
27	4	9	5	5	3	26	9	3	3	15
28	7	9	5	6	3	30	7	5		
29	7	6	7	4	4	28	4	5	8	17
30	6	9	2	6	7	30	2	7	13	22
31	9	6	3	6	6	30	5	3	12	20
32	3	12	6	7	2	30	5	3	4	12
33	6	7	0	7	5	25	7	5	17	29
34	8	2	0	4	1	15	5	6	5	16
35	3	9	4	1	2	19	3	2	4	9
36	8	8	7	4	9	36	0	6	13	19
37	7	11	7	7	6	38	8	6	3	17
38	7	10	6	7	2	32	7	6	14	27
39	7	10	6	7	0	30	0	5	13	18
40	7	6	4	3	2	22	3	4	8	15
41	8	9	8	7	7	39	4	3	6	13
42	4	11	7	5	9	36	4	4	4	12
43	6	8	6	6	4	30	7	4	13	24
44	0	10	5	6	5	26	3	4	20	27
45	8	12	5	5	2	32	9	8	17	34
46	6	6	0	2	2	16	2	4	12	18
47	9	9	5	5	3	31	9	3		
48	8	9	2	7	8	34	7	6	8	21
49	7	10	7	7	0	31	5	6	14	25
50	7	10	2	5	3	27	0	0	1	1
51	7	11	6	6	4	34	0	2	12	14
52	7	6	1	5	5	24	5	6	6	17
53	9	10	3	7	8	37	9	7	12	28
Third Grade										
54	6	10	6	5	9	36	9	7	11	27
55	7	12	9	5	9	41	8	6	12	26
56	8	12	3	6	8	37	10	9		
57	6	7	4	3	5	25	8	6	13	27
58	10	10	7	6	5	38	7	6	13	26
59	0	9	4	4	0	17	8	5	9	22
60	6	8	7	5	8	34	8	7		
61	6	11	4	6	5	32	9	8		
62	7	12	8	4	4	35	9	7	20	36
63	8	11	8	5	4	36	6	4	20	30

TABLE II (Continued)
Third Grade (Continued)

	Perceptual Tests						Symbol Tests			
Case	1	2	3	4	5	Total	6	7	8	Total
64	9	10	8	5	7	39	5	7	14	26
65	8	9	4	4	9	34	10	9	13	32
66	9	7	3	5	7	31	8	8	12	28
67	8	11	4	7	6	36	9	4	15	28
68	8	12	7	7	4	38	10	6	10	26
69	6	12	6	7	9	40	7	3	17	27
70	6	8	5	5	7	31	9	6		
71	9	11	6	7	7	40	8	6		
72	7	12	7	7	8	41	10	3	16	29
73	8	10	6	7	7	38	10	10	26	46
74	8	12	7	6	9	42	10	9	17	36
75	5	10	3	2	9	29	9	6	9	24
76	7	11	5	7	4	34	8	9		
77	7	10	7	7	5	36	6	9	17	32
78	0	10	7	5	7	29	6	5	13	24
79	6	12	5	6	8	37	6	9		
80	8	11	9	7	7	42	9	7	20	36
81	9	11	7	7	9	43	10	7	9	26
82	8	11	8	5	6	38	9	6	25	40
83	3	9	4	5	6	27	8	5	13	26
84	9	12	9	6	1	37	9	4	13	26
85	8	8	6	5	9	36	10	8	22	40
86	8	12	4	7	7	38	9	7	9	25
87	8	10	9	5	8	40	7	6	17	30
88	5	8	6	0	0	19	8	6	22	36
89	10	10	9	7	6	42	9	8	19	36
90	11	11	7	6	8	43	9	9	13	31
91	9	11	10	7	9	46	10	9	10	29
92	8	11	7	7	9	42	8	7	20	35
93	6	11	4	6	7	34	8	6	18	32
94	10	12	8	7	7	44	9	6	15	30
95	8	9	6	7	7	37	8	4	20	32
96	11	11	7	7	8	44	10	8	20	38
97	6	7	6	7	8	34	10	7	19	36
98	10	11	6	7	4	38	7	7	23	37
99	7	12	8	7	7	41	10	4	7	21
100	8	10	9	7	5	39	10	7		
101	8	11	6	7	6	38	9	9	13	31
102	9	12	6	7	7	41	10	7	15	32
103	8	11	8	7	5	39	9	5	20	34
104	10	10	8	7	8	43	10	8	19	37
105	8	12	6	7	8	41	8	7	21	36
106	9	10	6	6	1	32	5	7		
107	7	10	7	7	8	39	9	7		
108	7	9	6	7	5	34	10	7	26	43
109	7	11	8	7	8	41	8	5		
110	7	7	7	5	6	32	6	5	20	31
111	8	11	4	5	1	29	8	7		
112	9	11	9	6	9	44	9	8	17	34
113	5	11	6	7	8	37	9	7		
114	8	10	6	7	7	38	9	8	17	34
115	9	11	7	7	7	41	8	8	21	37
116	7	10	1	7	8	33	8	8	17	33
117	8	10	6	6	7	37	9	5		
118	8	10	3	7	7	35	9	7		

Table II (Continued)

Fourth Grade

	Perceptual Tests						Symbol Tests			
Case	1	2	3	4	5	Total	6	7	8	Total
121	8	10	7	7	4	36	7	9	11	27
122	7	11	5	7	9	39	8	6	18	32
123	7	9	0	6	7	29	8	4	16	28
124	10	12	9	6	8	45	9	8	14	31
125	7	12	9	7	8	43	10	9	22	41
126	9	11	9	7	4	40	9	6	20	35
127	7	11	8	7	8	41	8	10	19	37
128	7	10	3	7	1	28	10	7	23	40
129	9	10	9	6	7	41	9	9	14	32
131	9	11	9	7	9	45	6	7	17	30
132	10	9	3	6	1	29	8	8	14	30
133	12	11	6	7	9	45	10	9	19	38
134	9	12	6	7	6	40	10	7	21	38
135	9	10	5	6	4	34	8	2	19	29

On the theory expressed at the beginning of this second study that the contrast between high and low I. Q. would be less in lower than in upper grades, one would expect to find coefficients of correlation for perceptual tests and for symbol tests not quite so far apart as they were in the upper grade study, although he would still expect to find that the symbol tests correlated higher with mental age than the perceptual tests did. Examination of data in Table III (below) will show to what degree this expectation is realized.

Table III

Correlation of the Individual and the Combined Group Tests with Mental Age (Binet).

I. Perceptual Tests		II. Symbol Tests	
I. Symbol Digit	.39	I. Practical Judgment	.62
II. Picture Completion	.46	II. Opposites	.56
III. Maze	.39	III. Vocabulary	.72
IV. Pictorial Sequence	.47		
V. Pictorial Identities	.39		
Total Perceptual	.58	Total Symbol	.72

Comparison of this table with Table V of the first study shows that the predicted tendency for the correlation coefficients to run lower in lower grades is present especially in the battery of perceptual tests as compared with the battery of symbol tests. Neither battery shows so high a correlation as was shown by the corresponding battery in the first study. The relative relationship is, however, the same. The perceptual tests are always lower.

The vocabulary test in this table shows again the highest correlation found for any single test, but not quite so high as in the former study. All of this is significant, but it still needs to be reinforced by the computation of the index showing per cent of capacity in the two types of tests.

As before, in making these contrasts, the cases were first distributed by chronological age and I. Q.

TABLE IV

Chronological Age and Binet I. Q.

Case	7 yrs.	I.Q.	Case	8 yrs.	I.Q.	Case	9 yrs.	I.Q.
1	7-6	100	4	8-1	87	12	9-0	69
2	7-2	108	5	8-7	106	22	9-11	88
6	7-3	100	8	8-1	102	40	9-5	77
7	7-6	103	15	8-0	85	41	9-7	83
9	7-9	100	17	8-0	96	54	9-1	94
10	7-7	99	20	8-5	112	62	9-3	112
11	7-11	85	23	8-2	98	65	9-4	120
14	7-8	100	26	8-6	106	76	9-10	102
16	7-1	102	32	8-9	91	80	9-6	107
18	7-6	100	33	8-6	97	83	9-4	91
19	7-5	117	34	8-4	87	84	9-10	84
21	7-5	111	36	8-8	105	86	9-2	102
24	7-11	107	37	8-8	105	87	9-4	102
25	7-0	128	38	8-8	105	88	9-5	106
27	7-1	120	39	8-9	100	90	9-6	113
28	7-8	107	43	8-10	102	92	9-6	106
29	7-7	82	47	8-0	103	93	9-6	104
30	7-6	113	48	8-3	107	94	9-3	100
31	7-0	127	49	8-4	96	96	9-9	122
35	7-11	98	51	8-4	99	99	9-10	95
42	7-10	112	55	8-5	135	100	9-11	105
44	7-11	117	56	8-7	113	102	9-4	96
45	7-9	116	57	8-10	102	103	9-9	87
46	7-11	101	58	8-5	122	108	9-8	111
50	7-6	109	59	8-1	111	111	9-2	117
52	7-11	92	61	8-10	128	112	9-2	105
53	7-7	105	63	8-3	87	113	9-7	107
60	7-8	107	64	8-2	101	114	9-6	106
74	7-8	144	66	8-9	88	115	9-5	103
75	7-6	126	67	8-1	119	117	9-8	104
77	7-11	113	68	8-9	100	119	9-5	115
85	7-6	143	70	8-5	107	125	9-3	155
			71	8-3	106	135	9-10	106
			72	8-10	99			
			73	8-11	143			
			78	8-1	83			
			79	8-11	102			
			81	8-11	116			
			82	8-6	109			
			89	8-6	103			
			104	8-10	129			
			107	8-11	129			
			116	8-10	120			
			131	8-8	123			

The contrasts which follow are based upon an analysis of score (for the data see Table II) and chronological age and I. Q. (for data see Table IV). The method is the same as that used in the first study.

TABLE V

Contrast of Achievement of Low and High I. Q. in Perceptual and Symbol Tests.

	Perceptual Tests		Symbol Tests	
	Median	Index	Median	Index
	Chronological Ages 7 and 8			
Low I. Q.	29.5	.843	20.0	.769
High I. Q.	35.0		26.0	
	Chronological Ages 8 and 9			
Low I. Q.	30.0	.789	23.0	.718
High I. Q.	38.0		32.0	

Indices for other contrasts are as follows: (Index for total perceptual tests differs from that just given above because different number of cases were used).

TABLE VI

	Perceptual Tests	Symbol Tests 6 and 7
	Index	Index
Yrs. 7, 8	.805	.666
Yrs. 8, 9	.786	.656

	Perceptual Tests	Symbol Tests 8 alone
	Index	Index
Yrs. 7, 8	.843	.720
Yrs. 8, 9	.789	.588

In all of these contrasts the index for symbol tests is smaller than that for perceptual tests. This showing is therefore in all cases favorable to the original proposition that the achievement of low and high intelligence would be found closer together on the perceptual than on the symbol level. It should be noted, however, that the contrasts in these lower grades tend to be narrower than the ones previously shown for upper grades. This is in line with the theory previously expressed that mere age itself (as well as difference in high and low I. Q.) makes a difference in achievement in perceptual tests contrasted with symbol tests.

The study therefore consists in the same steps as those outlined for the first study, and the conclusion from it is the same, with additional evidence of the relationship of high and low school grade achievement. Thus it seems that the quantitative data presented in the two studies strengthen the conclusion previously arrived at through the theoretical survey of the field, and through the examination of evidences in the work of other investigators. It is fully appreciated that the number of cases used has been relatively small, and that the evidence furnished cannot be conceived to be finally conclusive. It is believed, however, that the evidence is now strong enough to warrant a definite conviction that further experimentation will confirm the tendencies shown in these studies. The relation of these conclusions to theories of intelligence and of intelligence measurement will be taken up in the next chapter.

CHAPTER VI

MODERN METHODS OF MENTAL MEASUREMENT

I. The evolution of modern methods.

I. A SUMMATION OF MODERN TENDENCIES

The intention here is not that of giving an exhaustive account of every attempt which has been made to measure intelligence; but rather that of identifying significant modern movements, and of pointing out definite tendencies, which have led to a present prevailing attitude toward the problem.

Previous to the early years of the twentieth century, diagnosis of mental subnormality was made mostly either by physicians from the medical standpoint, or by teachers from the pedagogical standpoint. There was very little of the psychological, except as it was implied in the others. Moreover, neither the medical nor the pedagogical diagnosis had much of the exact quantitative about it; but both were made mostly in the form of estimate, personal opinion, or approximation, very much akin to such estimates of distance as those expressed in terms of "a stone's throw," "a day's travel," etc. There were no standardized units and therefore no reliable, comparable results. It is true that degrees of feeblemindedness were discriminated in such words as idiot, imbecile, or the French "débile"; but the patient called imbecile by one physician might be called idiot or débile by another. There was no common ground upon which the diagnosis was made. The degrees of feeblemindedness were named in words of psychological import, but were sometimes defined in physiological or anatomical terms (brain lesion, control of bodily functions, motility, locomotion, prehension, appetite, respiration, secretion, circulation, or bodily stigmata) and sometimes in terms of specific mental functions (sensation, perception, will attention, etc.).

All of these attempts to define feeblemindedness, and its degrees, resulted in little attention to the need for defining intelligence, or for getting at its fundamental nature. It was apparently taken for granted that since intelligence is the opposite of feeblemindedness it was therefore well enough understood what intelligence is. Yet, both for feeblemindedness and intelligence, no terms at all would have been safer than the ones in use, because the very vagueness of the customary terminology gave a misleading impression of definitness. Such vagueness even made it possible to confuse feeblemindedness (retarded mentality) with insanity (unbalanced mentality), a thing which could not happen at the present time except among those entirely uninitiated in the field.

It is true that in the latter part of the nineteenth century a movement appeared which had in it more of the psychological and more of the exact quantitative. It is now known, however, that this psychological movement was fundamentally on the wrong track in so far as intelligence was concerned, although it had in it something which has survived. The movement in question showed two aspects: (1) the determination of intelligence through the exact laboratory measurement of individual mental and physical traits found to be correlated with the estimates, opinions, and approximations previously mentioned; and (2) the determination of intelligence through the summation of the results of exact quantitative measurement of mental traits regarded as elements. Thus intelligence was tacitly held to be equal to the sum of one's quantitatively measured sensation, perception, memory, etc.

The first of these tendencies (the correlation of intelligence with mental and physical traits) holds its place today as a valuable supplement to the scientific measurement of intelligence itself. The second has been discarded along with the "faculty" psychology out of which it sprang, except that the mental element or trait, regarded as a unit-mental activity, still holds a very important place when viewed from a different angle.

However, the real revolution in the definition and measurement of intelligence came when, through the genius of Binet, all criteria of intelligence (the medical criterion, the social criterion, the pedagogical criterion) were made subordinate to a perfected quantitative psychological criterion based upon the theory of *general* intelligence. The essence of this idea of general intelligence has already been given in the quotations of a previous chapter which deals with *judgment* as the common factor in intelligence and with the relation of the separate mental functions to intelligence. The customary exaggerated reliance upon the determination of amount of intelligence through its correlation with mental and physical traits was reduced to its rightful minor place, and the attempt to determine the amount of intelligence through the summation of mental traits was shown to be faulty. Then a relatively exact quantitative scale for the measurement of general intelligence was made. This scale is too well known to need description here. It was based upon judgment as a common factor in all intelligent acts, and although Binet did not hold absolutely to the use of problems involving judgment, the following quotation shows that, at bottom, that was his intention.

* "As a result of all this investigation, in the scale which we present we accord the first place to judgment; that which is of importance to us is not certain errors which the subject commits, but absurd errors, which prove that he lacks judgment. We have even made special provision to encourage people to make absurd replies. In spite of the accuracy of this directing idea, it will be easily understood that it has been impossible to permit of its regulating exclusively our examinations. For example, one cannot make tests of judgment on children of less than two years when one begins to watch their first gleams of intelligence. Much is gained when one can discern in them traces of coördination, the first delineation of attention and memory. We shall therefore bring out in our lists some tests of memory; but so far as we are able, we shall give these tests such a turn as to invite the subject to make absurd replies, and thus under cover of a test of memory, we shall have an appreciation of their judgment."

Binet's two proposals: (1) to make exact quantitative measurement of general intelligence; and (2) his later adopted plan of grouping together at one age all of the tests normal for that age, have proved to be the dominant features of modern intelligence measurement. The only notable competitor is what is known as the "Point Scale System" which adopts the idea of general intelligence, but rejects the chronological-mental age classification, and measures intelligence in "points won". But this proposal has been shown by Otis and by others to be not fundamentally different from the Binet method.

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* The Development of Intelligence, Vineland Laboratory, page 43.

Binet's work was first introduced to this country by Goddard, who made an American revision of it. Kuhlmann and others have also offered revisions; but the last and easily the most universally successful and important is Terman's Stanford Revision.

Important variations of the Binet plan appear in the "performance scales" and in group intelligence testing. The former have been referred to in previous chapters, especially as to their relation to levels in intentionally controlled intelligence. It needs to be emphasized here that these scales, built either upon the Binet plan or upon the essentially similar "point scale" plan, have great potential value for the measurement of non-English speaking foreigners, of the illiterate, the deaf, etc., but as general scales of intelligence they fail because they feature, in the main, the perceptual level only. Since it has been shown to be probable that both high and low intelligence can work at this level, it might be possible to get differentiation by the use of very many graded and especially carefully standardized tests; but this would not be an economical method in comparison with scales which use more abstract material. Neither would it be logical to attempt entirely to overcome the difficulty by complicating perceptual tests with abstract factors, although under certain conditions this approach is well worth while. Therefore the performance scale is inadequate as a total plan for grading intelligence, but it remains an essential subsidiary element for use under certain special conditions.

Examples of the most commonly known of the performance tests are those of Pintner and Patterson, Healy, Knox, Stenquist, and Kent. The Porteus maze tests are of this nature also; but are complicated more than some of the others by abstract requirements. They therefore are proportionately valuable, although the narrow range of judgment tested by them makes it desirable that they should be used as an element in a scale with other tests rather than by themselves.

As to modern group testing, it may be said that it was first introduced by Otis, that it adapts for group work certain tests similar to the individual Binet tests, and that it involves no new principles antagonistic to the Binet, although Otis suggests supplementary mathematical bases which provide for what he terms "an absolute point scale" in distinction from the point scale of the Yerkes-Bridges type. There can be no doubt that the more rapid work which the group method permits makes it of supreme importance, since it can be used for the bulk of the work with large numbers and the special cases can then be handled through individual tests.

Some of the best known of the group tests are those of Otis, and the army tests based primarily upon the Otis tests. The latter show the same tendency to divide into perceptual and symbol tests as has already been noted in the individual tests, and the fundamental reason for the division is the same. Illiterates and foreigners in the army could not be handled on the basis of tests requiring much use of language. Hence the development of the army group test Beta, and the utilization in the army also of many of the individual performance tests of the type of the Pintner and Patterson, Healy, Stenquist, Porteus, and others. Other group tests of the same general character as the army tests are the Pressey tests, the Haggerty tests, the Myers Mental Measure, the new National Research Council tests, Terman's Mental Ability tests for grades VII to XII, etc.

But all mental measurement of today has swung to the Binet principles, and the Binet criterion easily remains the dominating force in modern intelligence measurement. However, the results from the Binet tests, and their variations, are supplemented wherever possible by other psychological, pedagogical, and neurological data. There is also, where possible, a provision for retests, and for a period of observation of the subject before the final interpretation is made of the data. Persons with little more than a clerk's knowledge of the standard procedure can do much in the gathering of data, but where serious issues are involved, the interpretation calls for the widest experience and training in psychology and in the related sciences involved.

2. SOME GENERAL SIDE LIGHTS ON THE DEVELOPMENT OF THE MODERN VIEW.

But the modern view has come only as the culmination of a long conflict with the former preconceptions concerning intelligence. A brief discussion of the most salient points of this conflict will still further clarify the situation. There was for a long time (and one might almost say that there still is) a tendency to cling to the earlier medical and psychiatric conceptions wherein the criteria of feeblemindedness are expressed in physical, medical, social, or vague psychological terms rather than in the more definite concept of general intelligence and mental age. Binet's work was well along in France by 1908, yet in that year "The British Royal Commission on the Feebleminded" defined that class as "persons who may be capable of earning a living under favorable circumstances, but who are incapable from mental defect existing from birth or from an early age: (a) of competing on equal terms with their normal fellows; or (b) of managing themselves and their affairs with ordinary prudence". Such a definition, though vaguely psychological as well as social, is open to any interpretation which varying conditions and the personal equation of the physician or the psychiatrist may develop. It has nothing of the stability which is possessed by a mental age established through the use of a standardized scale.

But even Tredgold's original formulation was of the same order, although it included incomplete cerebral development (psychological criterion) as well as mental defect. Even as late as 1914 he defined amentia as "a state of restricted potentiality for, or arrest of, cerebral development, in consequence of which the person affected is incapable at maturity of so adapting himself to his environment or to the requirements of the community, as to maintain existence independently of external support." Thus in this definition there is the vague psychological criterion, the medical or physiological criterion, the social criterion, and also the more modern criterion of "adaptation"; and yet all are so indefinite as not to compare in any way with more exact scientific measurement based upon a standard psychological scale.

There has persisted also an effort to determine amount of intelligence through the correlation with bodily and mental traits and through the summation of mental traits measured quantitatively. The former is valuable if recognized and given its rightful subordinate position. Much good work has been done along this line as supplementary to diagnosis by the Binet and similar scales.

As to the attempt to get at intelligence through the quantitative summation of mental traits, it may be said that this is less and less in evidence. Some of the important places where it has tended to persist are the profile method of Rossilimo (1912), the tachistoscopic method proposed by Netschajeff (1917), and in the Yerkes-Bridges Point Scale. The authors of the latter arrange tests according to individual functions, but that part of their work has had little emphasis or apparent success and the scale has filled an important place through its resemblance to the Binet method, rather than because of the feature under discussion. Indeed such an effort can only have success when the subject is tested, not for the amount of the function, but for his ability to solve problems in terms of the function; and although this may have really been what the Yerkes-Bridges scale was meant to do, the authors do not make it clear that such was their idea.

3. CERTAIN MINOR AND MAJOR VIEWS AND STUDIES IN CONFIRMATION OF THE EXISTENCE OF A COMMON FACTOR FOR INTELLIGENCE.

Meumann, Stern, and Ebbinghaus have, in a general way, presented the idea of a common factor, particularly in the definitions which they give of intelligence. Meumann, as interpreted by Terman, presents a two-fold definition: "From the psychological point of view, intelligence is the power of independent and creative elaboration of new products out of the material given by memory and the senses. From the practical point of view, it involves the ability to avoid error, to surmount difficulties, and to adjust to environment." Stern says that intelligence is "the general capacity of an individual consciously to adjust his thinking to new requirements; it is general adaptability to new problems and conditions of life." Ebbinghaus, as a result of the Breslau investigation in 1905, came to take a view of intelligence which emphasized the ability to combine dissociated elements into a meaningful whole. He called this "combinative ability", and developed a tentative method for testing it, through asking the subject to fill in elisions in mutilated prose. This method has been further developed in many ways since that time, and is a common feature as a single test among groups of tests in most modern systems. Sentence completion, picture completion, etc., are variations of this test.

Intelligence has also been conceived as synonymous with a common mental factor called attention, clear awareness, concentration, etc.; and with other single mental factors; but it is very easy to believe that Meumann, Stern, Ebbinghaus, and other authorities of major importance support, in effect, the view of Binet which makes judgment the essential and common factor. Where other factors are named it seems clear that their advocates have definitely, even if unconsciously, identified intelligence with judgment and simply have made a further identification of what they conceive the central element in the process.

But the most convincing evidence of the existence of the common factor is the mathematical proof found in the correlational studies of such writers as Abelson, Burt, and Hart and Spearman. As to the essential nature of this generally conceded common factor there is a certain amount of disagreement. Abelson (1911) leaned toward "clear awareness", the lack of which in any case he refers to cerebral impairment. Burt supports essentially the same view when in his earlier work (1911) he combines Binet's tendency to emphasize the power of voluntary attention, with McDougall's view of the physiological factors in attention. But Burt also emphasizes judgment, reasoning, seeing relations, as the most fundamental things in intelligence, and suggests a scale of tests featuring all processes from the highest to the lowest (regarding reasoning as the highest). Thus he demands both complexity and range, with reasoning given the most weight. The difference between this view and that which has been urged in these pages lies in the fact that Burt appears to see levels of intelligence delimited by quantity of judgment ability, while herein the levels discriminated depend upon quality of judgment ability.

Spearman and Hart (see British Journal of Psychology, March 1912) discuss three views of the common factor: (1) non-focal, (2) multi-focal, and (3) uni-focal. In the first, abilities are regarded as absolutely specific, and therefore non-correlating, except in cases where, by chance, like elements happen to be present in the different performances. In the second, faculties, types, or levels are regarded by them as furnishing foci of likenesses, and therefore of groups of correlations, such as might be expected from Thorndike's theory of levels of sensitivity, association, and dissociation. In the third there is assumed to be a common factor in all performances, and therefore all performances may be expected to correlate to the extent to which the common factor is present.

While admitting the essential truth of the Spearman and Hart position, there are several observations which may be made. (1) The non-focal theory can, as they say, probably safely be discarded. Modern psychological investigation by Coover, Angell, Rugg, and others supports this conclusion. (2) The opinion of Spearman and Hart that the multi-focal theory is necessarily antagonistic to the uni-focal theory is not necessarily true if one admits the view that the common factor, judgment, extends through all intelligence; but that in a certain part of the field the quality of judgment is mechanical (thus differentiating mechanically controlled intelligence), and in another part of the field, purposive (thus differentiating intentionally controlled intelligence). Thorndike's sensitivity and association levels would then seem to belong to the field of mechanically controlled intelligence, while his dissociation (free idea) level, would seem to belong to intentionally controlled intelligence. Moreover in the field of intentionally controlled intelligence, the common factor, judgment, may again be conceived as determining levels according to the quality of the mental elements (sensations, percepts, images, symbols) between which relationships are discerned. (3) The theory thus interpreted does not involve "faculty" psychology if the mental elements considered are thought of as unit-activities of a total mind. (4) The whole theory supports the Binet view. It is true that Binet called the common factor judgment, and Spearman and Hart (and others) define it in terms of cortex energy, etc., but this may be viewed as only a case of psycho-physical parallelism in the analysis of which one person speaks in terms of the mental correlate, and the other in terms of the physical correlate. When the cortical change comes, the judgment is exercised. It is not necessary to postulate that one is caused by the other, but only that one accompanies the other.

Hence, there is a very generally supported view of the existence of a common factor, which factor can, roughly at least, be measured objectively and expressed through the use of an age scale; and the Binet scale is the basis and universally used expression of the theory.

II. Possible results of the theory upon methods of mental measurement.

It should now be clear that the key to the theory proposed by the thesis is (1) such a definition of intelligence as makes non-predictable variation the paramount thing in it; (2) the acceptance of the theory of a common factor responsible for non-predictable variation, and quantitatively measurable in terms of an age scale; (3) an appeal to the literature and to original quantitative experimentation in support of a new understanding of intelligence based upon an analysis of *qualitative* differences in the common factor. Primarily the qualitative differences appealed to are referred to differences in power to handle the concrete and the abstract. The reader should hold it definitely in mind that no claim of originality is here made for the theory that intelligence is conditioned by different degrees of control over the concrete and the abstract. It has been shown that the intuitive psychology of the layman ferreted out that fact long ago. But an attempt has here been made to show the connection of this popular conception with that of psychological levels differentiated by varying abilities to manipulate judgment in terms of the mechanical and the intentional, and in terms of different unit-mental-activities within the intentional. Assuming that a certain amount of proof has been offered in favor of the hypothesis of levels conditioned by these qualitative differences in the common factor, and that there is at least a strong probability that the theory is true, the following practical bearings of this conclusion upon methods of mental measurement are suggested.

1. EMPHASIS UPON THE VALUE OF THE LANGUAGE TEST.

One result of the study is to emphasize the value of the language test as an intelligence test. By language test is not meant the mere mechanical flow of words; but instead a genuine command of language as the tool of thought. There has been a growing tendency in intelligence measurement to try to get away from the language test. This tendency has been one reason for the development and use of performance scales even with subjects who labor under no handicap with regard to language ability. However, the desire to minimize the language factor has had its origin largely in the fact that owing to their ability to put many words together, the feebleminded have often been found to give an impression of an intelligence which they do not really possess. Ideas expressed in language have two phases: (a) the word, or symbol, and (b) the meaning of the word or symbol. The feebleminded often have the first of these without the second. When the mechanical use of language can be sufficiently guarded against, language ability becomes one of the best evidences of intelligence, of ability to work on the symbol level in contrast to the perceptual level.

2. TENDENCY TO THE DEVELOPMENT OF MORE DIAGNOSTIC SCALES OF INTELLIGENCE BASED UPON THE SEPARATE SCALING OF QUALITATIVE DIFFERENCES IN THE COMMON FACTOR.

It seem likely that as a supplement to the single scale which now features mechanically controlled intelligence, intentionally controlled intelligence, and reproductive (pedagogical) intelligence, together, there will tend to appear also separate scales of these three types of intelligence constructed upon the same principles. In fact such an outcome is already in evidence. Reproductive, or pedagogical scales have become common; and De Sanctis, even as early as 1911, suggested the distinction between "lower ideation" and "higher ideation". This distinction corresponds in intent at least roughly to the mechanically controlled intellligence and intentionally controlled intelligence which have been discussed. The idea has also of late appeared in concrete operation in the work of Link and others in employment psychology. The investigators in this field have found it necessary to develop separate scales of *technique* and of *intelligence;* or, in other words, separate scales of mechanically controlled intelligence and of intentionally controlled intelligence. The very fact that practical application of tests has brought out the demand for three types of scales is in itself a degree of proof of the theory as outlined; and there is added proof in the tendency of modern students of intelligence to stress the intentional and immediate solution of problems as the central thing in intelligence. It is the central thing in the highest type of intelligence, the type differentiated by judgment of the intentionally controlled quality.

The present Binet scale, or any other perfected upon the same principles, can give a result which shows only a total mental age. One can ascertain that a subject is excellent or normal or feebleminded by comparison with chronological age, but neither the Binet mental age nor the intelligence quotient derived from it shows specifically wherein the excellence or the defect of the subject consists. The situation is similar to that which has developed with pedagogical scales. Take for example the field of handwriting. Thorndike's scale of "general merit" in handwriting is directly comparable with the Binet scale of general ability in intelligence. The scale measures a total ability, but does not attempt to be analytic or diagnostic as to particular faults. Such a scale has many values (and always will have), as "general merit" handwriting scales have abundantly proved; but it has been necessary for diagnostic purposes to develop supplementary scales of separate elements of handwriting excellence such as the Ayres division into slants and the more extended Freeman division into a larger number of parallel scales of important elements. With an opportunity to scale a pupil's handwriting by the several scales of the elements, that pupil's special difficulty can be located and the correct assistance given.

It seems probable therefore that there should be developed a scale or a system of scales which would measure separately not only mechanical, pedagogical, and purposive intelligence, but which also (in purposive intelligence at least) would measure separately the ability to judge (a) in terms of perceptual material, and (b) in terms of imaginal material, and (c) in terms of symbol material. Such a series of scales would be much more diagnostic than the general scales now in existence, would help correctly to place subjects in life, and, by more nearly locating the defect would lead the way to a more effective study of possible remedies for mental defects. This is extremely important, for it is not impossible that the present view of the permanency of mental defect needs at least partial revision. At least they need very extended and critical testing, and the more definite analysis which would be possible through the qualitative extension of the scales would be a very important assistance in this work.

3. INCREASED TENDENCY TO SPECULATE UPON THE PROBLEM AS TO WHETHER THE DEVELOPMENT OF INTELLIGENCE CEASES SOON AFTER ADOLESCENCE.

The emphasis upon judgment as the common factor in intelligence, and upon levels of intelligence determined by qualitative differences in the mental elements concerning which judgment is rendered, may throw light upon the vexed question as to whether the development of intelligence ceases at about the chronological age of sixteen or eighteen as the Binet theory tends to hold. All experiments with Binet material and procedure have tended to sustain this view. They have not brought out reliable evidences of increment beyond the point mentioned. Hence there is the inference that mental growth reaches approximately its maximum, as does physical growth, a few years after adolescence. Of course there may be after this time an increase in the ability to get the most out of the intelligence which one has, just as one may learn to make better and better use of his physique even after physical growth ceases; but to distinguish between increase in intelligence itself and increase in one's power to use a fixed amount of intelligence appears to some persons as, in a sense, a begging of the question. For, off hand, one tends to believe that if a college senior can solve more real problems than he could when he was a high school senior, then by that very fact he is to be judged actually more intelligent. By the same criterion he might be found more intelligent when he is chronologically forty than at the time of his graduation from college.

Yet the point in question is exactly the one just raised. Does a person show more success in problem-solving at forty than at sixteen or eighteen? Possibly the answer lies in asking whether one means *more* problem-solving or *better* (or different) problem-solving. Thus perhaps it is again a question between quantity and quality. In this thesis the view has been supported that the power to deal with abstractions must show development around about twelve years (chronologically) or else the subject is marked as mentally inferior. That is, he must begin to exhibit a certain quality of judgment at about that time or he is defective. By the time he is sixteen or eighteen the Binet tests seem to show that his power of abstraction is developed about as far as it ever will be, that significant increase in intelligence beyond this age does not seem to occur. Perhaps this appears to hold (a) because the peculiar quality of abstract judgment (organizing power) required to earn the new increment of intelligence is not tested by the Binet tests; and (b) because the peculiar quality of abstract judgment in question is so rare that it is easily missed by *any* system of tests. There is a type of abstract synthesis which requires not minutes or hours, but months, years, or a lifetime. Many of the world's supreme problems have been solved by men who have shown a peculiar, dogged persistency in pursuing an idea until its relation to other ideas and their relation to it became apparent. Speed is not an element in such a feat. The essence of the achievement is judgment of a peculiar organizing type, which sees through insignificant details and finally seizes upon the really significant factors. It may be, therefore, that after types of intelligence are differentiated on the qualitative basis of perceptual, imaginal, and symbolic, it will be necessary to distinguish a higher qualitative differentiation within the symbolic itself, which the limitation of brief time for testing, and incomplete insight into values, have left still untapped by any exact quantitative measurement. Perhaps it is too elusive to be tapped. At any rate, one may, if he so desires, speculate upon its existence, and he is likely to do so if he is not fully satisfied with the other view that intelligence ceases to develop at the age of sixteen or eighteen years. This speculation concerning a real increase in intelligence itself, an increase based upon qualitative differences in the power of abstract thought, is possibly not antagonistic to the essential Binet principles but merely supplementary to them.

III. *Summary.*

In this thesis it has been held:

1. That the problem of intelligence is within the problem of adaptation.
2. That not all adaptation, but only non-predictable adaptation is intelligent.
3. That in all non-predictable adaptation there is a common factor, judgment.
4. That sometimes the quality of judgment is mechanical and sometimes intentional.
5. That if the term intelligence is used at all with reference to mechanically controlled judgment, the qualified expression *mechanically controlled intelligence* should be used.
6. That intentionally controlled judgment should be called *intentionally controlled intelligence.*
7. That intentionally controlled intelligence itself exists in levels determined in popular language by different degrees of concreteness and abstractioness involved in the exercise of the common factor.
8. That the terms concrete and abstract are only popular expressions for the more technical psychological terms which designate unit-mental-activities.

9. That there could be discriminated as many levels in intentionally controlled intelligence as there are distinct unit-mental-activities; but that it is expedient to discriminate but three levels—the perceptual level, the image level, and the symbol level.

A degree of proof of the existence of the levels has been offered (a) by reference to existing literature, and (b) by original quantitative research. The conclusion is drawn that more diagnostic testing of intelligence could be done if the exising age-scales of general intelligence were supplemented by scales which test for ability on the different levels.

The main contributions are (a) greater insight into the definition and nature of intelligence, and (b) the pointing of the way toward more diagnostic measurement of intelligence through the provision for measurement based upon the levels determined by qualitative differences in the common factor, judgment.

TYPICAL GENERAL REFERENCES

Abelson, A. R., Measurement of Mental Ability of Backward Children, Br. Jr. Psychol., 4, 1911.

Adams, G. P., On the Negative and Positive Phototropism of the Earthworm, Am. Jr. Physiol., 9, 26.

Angell, J. R., Chapters from Modern Psychology, Longmans, 1912.

........, An Introduction to Psychology, Holt, 1918.

Baldwin, B. T., Differentiation Between Psychological Experiments and Mental Test., Report of Am. Psychol. Asso., 1916.

Baldwin, J. Mark, Mental Development, Macmillan, 1894.

........, The Development of Animal Psychology, Congres. int. de Zool., 1914.

........, Social and Ethical Interpretations, Macmillan, 1897-1902.

Balz, A. G. A., Dualism and Early Modern Philosophy, Jr. Philos., Psychol., etc., 1918, 15.

Bell, J. C., Recent Literature on the Binet Tests, Jr. Ed. Psychol., 3, 1912.

Binet, Alfred, et Simon, Th., Sur la necessité d'établir un diagnostique scientifique des états inférieurs de l'intelligence, L'Année psychologique, 1915, 163-190. See also pages 191-244, and 245-336.

........, Le Developement de l'intelligence chez les enfants, L'Année psychologique, 1908, 1-94.

........, Nouvelles recherches sur la mesure du niveau intellectuel chez les enfants d'ecole, L'Année psychologique, 1911, 145-201.

Binet, Alfred, Les Signes physiques de l'intelligence des enfants, L'Année psychologique, 1910.

........, Les Frontières anthropométriques des anormaux, Bu. Soc. Et. Ps. Enf., 1904.

........, Attention et adaptation, L'Anné psychologique, 1900; 248-404.

Boardman, H., (Compiler), Psychological Tests, a Bibliography, N. Y., Bureau Ed. Experiments, 1917.

Bobertag, O., Ueber Intelligenzprüfungen, Zeitschrift für angewande Psychologie, 1911, 5.

Bohn, G., Actions tropiques de la lumiere, c. r. Soc. Biol., Paris, t. 55.

........, Théorie nouvelle du phototropisme, c. r. Academy Science, t. 139.

Bonser, F. G., The Reasoning Ability of Children, Columbia University, Contributions, No. 37.

Book, W. F., Analysis of Some of the Higher Thought Processes, Psych. Bul., 1912, 9.

Brigham, C. C., Two Studies in Mental Tests, Psychological Monographs, 1917, 24.

........, An Experimental Critique of the Binet-Simon Scale, Jr. Ed. Psychol., 5, 1914.

Buckingham, Correlation Between Ability to Think and to Remember, Schl. and Soc., 1917, 5.

Burt, C., Experimental Tests of General Intelligence, Br. Jr. Psychol., 3, 1909.

........, Experimental Tests of the Higher Mental Processes, Jr. Exper. Ped., 1911, 1.

Carus, P., In Reply to Dualistic Conceptions of Mind, Monist, 1918, 28.

Cellérier, L., L'Habitude dans l'education, L'Educ., 1916.

Chase, H. W., Consciousness and the Unconscious, Psyc. Bul., 1916.

Chotzen, F., Die Intelligenzprüfungsmethode, Zeitschrift für angewande Psychologie, 1912, 6.

Clifford, W. K., Lectures and Essays, London, 1886.

Cohen, M. R., The Distinction Between the Mental and the Physical, Jr. Phil., Psychol., etc., 1917, 14.

Colvin, S. S., The Attitude of the Child in Learning, N. E. A., 1914.

Coover, J. E., Formal Discipline, Psych. Mon., 1912, No. 87. For other material on the same topic see also bibliographies in this book.

Dashiell, J. F., Sixteen Origins of the Mind, Am. Jr. Psychol., 1918, 29.

Dearborn, W. F., The Measurement of Intelligence, Psyc. Bul., 1917, 14.

De Busk, Height, Weight, Vital Capacity, and Retardation, Ped. Sem., 1913, 20.

Decroly and Degand, Archives de Psychologie, Jan., 1910.

De Sanctis, S., Mental Development and Measure of the Level of Intelligence, Jr. Ed. Psychol., 1911, 2.

Descoeudres, A., Equète sur l'evaluation subjective des quelques tests Binet et Simon, Archives de psychologie, 1917, 16.

Dewey, John, Duality and Dualism, Jr. Philos. Psychol., etc., 1917, 14.

........, Imitation, Encyclopedia of Education (Monroe), Macmillan, 1911.

........, The Reflex Arc Concept in Psychology, Psyc. Rev., 1893, 3.

........, How We Think, Heath, 1910.

Doll, E. A., A Brief Binet Scale, Psyc. Clinic, 1917, 11.

........, Anthropometry as an Aid to Mental Diagnosis, Vineland, N. J., 1916.

........, The Interpretation of Anthropometric Measurements, Jr. Psycho-Aesthenics, 1915, 20.

Downey, J. E., Standardized Tests and Mental Inheritance, Jr. Hered., 1918, 9.

Dunlap, K., An Outline of Psychobiology, Johns Hopkins Press, 1917.

Ebbinghaus, Ueber eine neue Methode zur Prüfung geistigen fähigkeiten, etc., Zeitschrift für Psychologie, 1897, 13.

Esquirol, Des Malades mentales, II, p. 340.

Fabre, F. H., The Wonders of Instinct, London, 1918.

Fernald, Guy C., An Achievement Capacity Test, Jr. Ed. Psyc., 1912, June.

Franz, S. I., Handbook of Mental Examination Methods, Jr. Neur. and Mental Diseases Pub. Co., 1912.

Fisher, S. C., The Process of Generalizing Abstraction and Its Product the General Concept, Psyc. Mon., 1916, 21.

Galton, Head Growth in Students at the University of Cambridge, Nature, 1888, 38; 1889, 40.

........, Cambridge Anthropometry, Nature, 1890, 41.

Gilbert, Researches on Mental and Physical Development of School Children, Yale Psychological Studies, 1894, 2.

........, Researches upon Children and College Students, University of Iowa, 1897, 1.

Goddard, H. H., Psychology of the Normal and Subnormal, Dodd, Mead and Co., 1919.

........, The Binet and Simon Tests, 1905 Series, Vineland, 1908.

........, Measuring Scale of Intelligence, Vineland, Jan., 1910.

Goddard, H. H., Four Hundred Feeble-minded Children Classified by the Binet Method, Ped. Sem., 1910, 17.

........, The Revision of the Binet-Simon Scale, Vineland, 1911.

........, The Form Board as a Measure of Intellectual Development in Children, Training School Bulletin, 1912, 9.

........, Standard Methods of Scoring Binet Tests, Vineland, April, 1913.

........, The Reliability of the Binet-Simon Measuring Scale of Intelligence, Proc. Fourth International Congress of School Hygiene, 1913, 5.

........, Two Thousand Normal Children Measured by the Binet Measuring Scale of Intelligence, Ped. Sem., 1911, 18.

Gray, W. S., Descriptive List of Standard Tests, Elementary School Journal, 1916, Sept.

Groos, The Play of Animals, Chapman and Hall, 1898.

Groszmann, M. P. E., The Individual Child, Scribners, 1917.

Hall, G. Stanley, The Founders of American Psychology, Appleton, 1912.

........, Adolescence, Appleton, 1904.

Hachet, Souplet P., La Genese des instincts, Paris, 1912.

Hart and Spearman, General Ability; its Existence and Nature, Br. Jr. Psychol., 1912, 5.

Healy, William A., Pictorial Completion Test, Psychol. Rev., 1914, 21.

........, The Individual Delinquent, N. Y., Little Brown, 1915.

Healy and Fernald, Tests for Practical Mental Classification, Psyc. Mon., 1911, 54.

Herrick, C. Judson, An Introduction to Neurology, Saunders, 1915.

Holmes (etc.), Descriptive Bibliography of Measurement in Elementary Subjects, Harvard Bulletin, 1917.

Höningswald, R., Principien der Denkpsychologie, Kant. Stud., 1913-8.

Hough, The Classification of Nervous Reactions, Science, N. S., XLI.

Huey, E. B., The Psychology and Pedagogy of Reading, N. Y., 1908.

........, Backward and Feebleminded Children, Baltimore, Warwick and York, 1912.

James, William, Psychology, Holt, 1890.

Jennings, H. S., The Behavior of the Lower Organisms, N. Y., 1906.

Johnson, W. E., Analysis of Thinking, Mind, 1918, 27.

Klemm, Otto, A History of Psychology, Scribner, 1914.

Kohs, S. C., The Stanford (1915) and the Vineland (1911) Revisions of the Binet Scale, Psyc. Rev., 1917, 24.

........, The Binet-Simon Measuring Scale for Intelligence, an Annotated Bibliography, Jr. Ed. Psychol., 1914, 5.

Knox, H. A., A Scale Based Upon the Work at Ellis Island, Jr. Am. Med. Asso., March, 1914.

Kuhlman, F., A reply to Dr. L. P. Ayres, etc., Jr. Psycho-Aesthenics, 1911, 16.

........, Binet and Simon Method for Measuring Intelligence of Children, Jr. Psycho-Aesthenics, 1911, 15.

........, Some Results of Examining 1000 Public School Children with a Revision of Binet-Simon Tests of Intelligence by Untrained Teachers, Jr. Psycho-Aesthenics, 1914, 18.

........, The Binet and Simon Tests of Intelligence in Grading Feebleminded Children, Jr. Psycho-Aesthenics, 1912, 16.

........, A Revision of the Binet-Simon Scale for Measuring Intelligence of Children, Mon. Sup. Jr. Psycho-Aesthenics, Sept. 1912.

........, A Further Extension and Revision of the Binet-Simon Scale, Jr. Criminal Law, 1918, 8.

........, What Constitutes Feeblemindedness, Jr. Psycho-Aesthenics, 1915, 19.

Külpe, Outlines of Psychology.

Ladd, Psychology, Descriptive and Explanatory, Scribners, 1909.

Ladd and Woodworth, Elements of Physiological Psychology, Scribners, 1911.

Lange, K., Ueber Apperzeption, Leipzig, 1912.

Lashley, K. S., Recent Literature on Animal Behavior, Psyc. Bul., 1914, 11.

Lindley, A Study of Puzzles, Am. Jr. Psychol., 8.

Lillie, R. S., What is Purposive and Intelligent Behavior, Jr. Phil. Psychol., etc., 1915, 12.

Lloyd, A. H., Psychophysical Parallelism, Jr. Phil. Psychol., etc., 1917, 14.

Loeb, J., Comparative Physiology of the Brain and Comparative Psychology, N. Y., 1900.

........, Concerning the Theory of Tropisms, Jr. Exper. Zool., 151, 4.

Loeb, J., The Mechanistic Conception of Life, Chicago, 1912.

........, The Organism as a Whole from a Psychochemical Viewpoint, Putnam, 1916.

McKenzie, J. S., Laws of Thought, Mind, n. s. 1916, 25.

McMurry, F. M., How to Study, Houghton Mifflin, 1909.

Marbe, K., Zur Psychologie des Denkens, Fortsc. d. Psychologie, 1914, 3.

Marratt, R. T., Anthropology and University Education, Rep. Brit. Asso. Adv. Sc., 1916.

Marshall, H. R., The Relation of Instinct and Intelligence, Br. Jr. Psychol., 1912, 5.

Mead, The Relations of General Intelligence to Certain Mental and Physical Traits, N. Y., Teachers College, 1916.

Meumann, Vorlesungen, Leipsig, 1907.

Morgan, Animal Behavior, Longmans, 1900.

National Society for Scientfic Study of Education, Material on Standard Tests: 15th and 17th Year Books.

Netschajeff, A New Method for the Investigation of Intelligence, Jr. Exper. Ped., 1917, 4.

Norsworthy, Naomi, The Psychology of Mentally Deficient Children, N. Y., Teachers College, 1906.

Otis, A. S., Some Logical Aspects of the Binet Scale, Psyc. Rev., 1916, 23.

........, A Criticism of the Yerkes-Bridges Point Scale, Jr. Ed. Psychol., 1917, 8.

........, An Absolute Point Scale for the Measurement of Intelligence in Groups, Jr. Ed. Psychol., 1918, 9.

Parker, G. H., Locomotion of Sea Anemones, Proc. Nat. Acad. Sci., 1916, 2.

Paulsen, Introduction to Philosophy, Holt, 1904.

Pearse and White, Recent Literature on Tropisms and Instinctive Activities, Psyc. Bul., 1915, 12.

Pearson, Karl, Grammar of Science, London, 1900.

Peterson, H. A., The Generalizing Ability of Children, Jr. Ed. Psychol., 1914, 5.

Pillsbury, Attention, 1908.

Pintner, R., The Standardization of the Knox Cube Test, Psy. Rev., XXII, 1915, 5.

Pintner and Patterson, A Scale of Performance Tests, Appleton, 1917.

Plate, L., Beobachtungen an den denkenden Pferden des Herrn Krall, Naturwiss Woch., 1913, 28.

Porter, The Growth of St. Louis Children, Trans. Acad. Sci., 1894, 6.

Porteus, D. D., Mental Tests for Feebleminded: a New Series, Jr. Psycho-Aesthenics, 1915, 19.

........, The Measurement of Intelligence: 653 children examined by the Binet and Porteus Tests, Jr. Ed. Psychol., 1918, 9.

Pressey, S. L., and L. W., A Group Scale for Measuring General Intelligence, Jr. Applied Psychology, 1918, 2.

Pyle, W. H., A Manual for the Mental and Physical Examination of School Children Univ. Mo., 1916, 17.

Quetelet, Anthropométrie, Brussels, 1871.

Rabinovitsch, S., Resulte der experimentellen Untersuchung von Kindern nach der kurtzen Methode von Rossilimo, Zsch. f. angewande Psychologie, 1918, 13.

Rádl, E., Untersuchungen über die Phototropismus der Tiere, Leipsig.

Romanes, G. J., Mind and Motion, Longmans, 1895.

Rosanoff, Martin, and Rosanoff, A Higher Scale of Mental Measurement, Psyc. Mon., 1918, 25.

Rosenow, C., The Analysis of Mental Functions, Psyc. Mon., 1917, 24.

Rossilimo, G., Mental Profiles, Jr. Exper. Ped., 1912.

Ruediger, W. C., Thought and the Higher Mental Processes, Psyc. Bul., 1918, 15.

Ruger, A. J., The Psychology of Efficiency, Archives of Psychol., 1910, 15.

Rugg, H. O., Experimental Determination of Mental Discipline, Warwick and York, 1916; contains Bibliographies on the Subject.

Sackett, L. W., The Canada Porcupine, a Study of the Learning Process, Animal Behavior Monographs, 1913, 2, No. 2.

Sellers, R. W., An Approach to the Mind-Body Problem, Philosophic Review, 1918, 27.

Shepherd, J. F., Habit Formation and Higher Mental Capacities in Animals, Psyc. Bul., 1917, 14.

Sherrington, The Integrative Action of the Nervous System, N. Y., 1906.

Simon, Recherches cephalometriques sur les enfants arriérés de la Colonie de Vaucluse, L'Année psychologique, 1900, 7.

Simpson, B. R., Correlations of Mental Abilities, N. Y., Teachers College, 1912.

Smedley, Annual Report to Board of Ed., Chicago, 1900-01; Also Com. Ed. Report, 1902, Vol. I.

Smith, E. M., The Investigation of the Minds of Animals, Cambridge University Press, 1915.

Sollier, Paul, Psychologie de l'idiot et de l'imbécile, Paris, 1901.

Spearman, C., General Intelligence Objectively Determined and Measured, Am. Jr. Psychol., 1904, 15.

Stern, William, The Psychological Methods of Testing Intelligence, (Tr. Whipple) Warwick and York, 1913.

Stratton, G. M., Experimental Psychology and Its Bearing Upon Culture, Macmillan, 1903.

Terman, L. M., Review of Meumann on Tests of Endowment, Jr. Psycho-Aesthenics, 1913, 5.

........, Suggestions for Revising, Extending, and Suplementing the Binet Intelligence Tests, Jr. Psycho-Aesthenics, 1913, 18.

........, Psychological Principles Underlying the Binet-Simon Tests, and Some Practical Considerations for its Correct Use, Jr. Psycho-Aesthenics, 1913, 18.

........, Genius and Stupidity, Ped. Sem., 1906, 13.

........, The Measurement of Intelligence, Houghton Mifflin, 1916.

........, The Vocabulary Test as a Measure of Intelligence, Jr. Ed. Psychol., 1918, 9.

........, The Intelligence of Children, Houghton Mifflin, 1919.

Terman and Chamberlain, Twenty-three Serial Tests of Intelligence, etc., Jr. Applied Pspchol., 1918, 2.

Terman and Others. Stanford Revision Monograph, Warwick and York, 1916.

Thorndike, E. L., Educational Psychology, Columbia University Press, 1913.

........, Animal Behavior, Macmillan, 1911.

Thompson, E. L., An Analysis of the Learning Process in the Snail, Behavior Monographs, 1917, 3.

Titchener, E. B., The Psychology of Feeling and Attention, Macmillan, 1908.

........, Description vs. Statement of Meaning, Am. Jr. Psychol., 1912, 23.

........, Experimental Psychology, N. Y., 1901.

Torrey, H. B., Tropisms and Instinctive Activities, Psyc. Bul., 1917, 14.

Trabue, M. R., Completion Test Language Scale, N. Y., Teachers College, 1916, 77.

Trebitsch, A., Die Sinn und das Denkin, Arch. f. syst. Phil., 1913, 19.

Tredgold, Mental Deficiency, London, 1914.

Trobridge, C. C., The Origin of the Flocking Habits of Migratory Birds, Pop. Sci. Monthly, 1914, 84.

Turner, C. H., The Locomotions of Surface-breeding caterpillars are not Tropisms, Biol. Bul., 1918, 34.

Tyndall, Fragments of Science, N. Y., 1874.

U. S. Surgeon General, Examiner's Guide for Psychological Examining in the Army, Washington, 1918.

Vervorn, M., General Physiology, London, 1899.

Veschide et Pelletier, Recherches sur les signes physiques de l'intelligence, Revue philosophique, 1903, 4.

Vincent, S. B., Literature for 1915 on the Behavior of Vertebrates, Jr. Animal Behavior, 1916, 6.

Warren, H. C., The Mechanics of Intelligence, Philos. Rev., 1917, 26.

Washburn, M. F., Tropisms and Instinctive Activities, Psyc. Bul., 1918, 15.

........, The Animal Mind, Macmillan, 1908.

Watson, J. B., Homing and Related Activities of Birds, Carnegie Institution, 1915.

........, Behavior, an Introduction to Comparative Psychology, Holt, 1914.

........, Psychology from the Standpoint of a Behaviorist, Lippincott, 1919.

........, An Attempted Formulation of the Scope of Behavioristic Psychology, Psyc. Rev., 1917, 24.

Weeks, A. D., The Crisis Factor in Thinking, Am. Jr. Soc., 1914, 19.

Weiss, A. P., Relation Between Functional and Behavior Psychology, Psyc. Rev., 1917, 24.

........, Relation Between Structural and Behavior Psychology, Psyc. Rev., 1917, 24.

Wigge, C., Das Problem der krallschen Pferde, Dusseldorf, 1913.

Winch, Binet's Mental Tests, Childstudy, London, 1913, 16.

Wissler, C., Correlation of Mental and Physical Tests, Psyc. Mon. 1901, 3.

Woodworth, Dynamic Psychology, Columbia Univ. Press, 1916.

Woodworth and Wells, Association Tests, Psyc. Mon., 1911, 5.

Wooley, Helen T., A New Scale of Mental and Physical Measurements for Adolescents, Jr. Ed. Psychol., 1915, 6.
Wundt, Grundriss der Psychologie, 1905.
........., Menschen und Thierseele.
........., Grundzüge der physiologische Psychologie, 1887.
........., Volkerpsychologie, 1900.
Wyatt, S., Quantitative Investigation of Higher Mental Processes, Br. Jr. Psychol., 1913, 6.
Yerkes, R., Behaviorism and Genetic Psychology, Jr. Philos. Psychol., etc., 1917, 14.
........., Objective Nomenclature, Comparative Psychology, and Animal Behavior, Jr. Comp. Neurology, 16, 380.
........., The Dancing Mouse, Macmillan, 1907.
Yerkes, Bridges, and Hardwick, A Point Scale for Measuring Intelligence, Warwick and York, 1914.
Yerkes and Yerkes, Individuality, Temperament, and Genius in Animals, Am. Mus. Jr., 1917, 17.
Ziehen, Die Principien und Methoden der Intelligenzprüfung, Berlin, 1919.

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Personnel Selection of Graduate Engineers

The Differentiation of Apprentice Engineers for Training as Salesmen, Designers, and Executives of Production

BY

BRUCE V. MOORE, Ph.D.
Bureau of Personnel Research, Division of Applied Psychology,
Carnegie Institute of Technology, Pittsburgh, Pennsylvania

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FOREWORD

This volume is a contribution to psycho-technology. Mr. Moore has made, in the following experimental and statistical study, the first approach toward a scientific solution of the problem of placement of engineering graduates in a great American industrial organization.

It is a bold and novel undertaking, characteristic of a young century, to essay the application of the principles and technique of scientific method to the solution of human problems in industry. Yet it needs no rare wit to see that these very problems of human adjustment must hold during the twentieth century the focus of study and invention which during the nineteenth century were chiefly concentrated on the problem of perfecting the mechanics of manufacture. Human engineering is destined to a development comparable to that experienced by mechanical, chemical, and electrical engineering, when they first began to draw largely on the lustily growing sciences of chemistry and physics. Thanks to the foundations laid by these sciences, modern industry has a highly developed technology of materials and processes. It asks now for a technology of human nature.

This study in principles and practices of personnel selection is not a popular treatise. But its appeal will be felt by at least three types of readers: the thoughtful leader of industry who ponders the trend of scientific experimentation on human problems; the young engineering graduate who is debating in his own mind whether to become a designer, a manager, or a salesman; and the psychologist who is watching, with some apprehension, the movement to put into practical use the tools he has forged.

W. V. Bingham,
Division of Applied Psychology,
Carnegie Institute of Technology.

PREFACE

This report is a description of a specific study on a practical problem. Certain principles and practices are proposed as conclusions from this study. The practical problem was to determine methods and means for selecting young engineers just being graduated from college and placing them in the type of work which they could do best in a large electric manufacturing company. The outstanding feature of the problem was to select the men best qualified to develop into sales engineers; that is, engineers who meet the public and sell electrical machinery. The study was made primarily to solve the practical problem; and then the principles underlying the solution were formulated in order that they might be applied to further problems. In other words, the research was made for service, in the belief that it was possible to give service and at the same time make a contribution to science.

As a practical investigation the work is already giving service. The results already obtained on one hundred seven engineers employed by the firm during the first year that the new methods recommended here have been used, are very similar to the results obtained on the group studied in this research. Assuming that the executives classified the men correctly at the end of a year, we can say that the results of the test alone would have classified seventy per cent of the men correctly on the day that they were employed. Beginning with June, 1921, the company will use the test and other methods recommended here as definite aids in classifying and placing graduate engineers whom they employ.

Progress in psychology, as in any other science, has been made by specialization and intensive study on a specific problem. Quite often in science both the motive and the opportunity has been a practical problem in industry. The growing realization that the human factor is a most important one in industry has given both motive and opportunities for research on specific problems in psychology, the science of human behavior. The business world is appealing to psychology as a science to solve specific problems. Some psychologists have already brought forth and exploited the facts, the technique, and the point of view of their science, in the hope that the science might be advanced as a science as well as be made to serve man in utilitarian ways. For accomplishing both purposes, the first and most important principle is that one definitely narrow and specific problem after another must be attacked and solved to contribute its portion to the cumulative content of the science.

This report of a study on such a specific problem has been written in a comparatively brief and concise form. It is intended for practical use; but also it is intended to be read in its entirety only by those who understand the language of psychology and statistical methods. The original tables of data are not presented; and much of the explanation is omitted which might be included in an exhaustive treatise. The tables and all other details of the study are on file with the Division of Applied Psychology, Carnegie Institute of Technology, and are available for all who may wish to examine them. However, it is believed that the report is sufficiently complete to enable those who have an intelligent interest in such a problem to grasp what the study has to give.

ACKNOWLEDGMENTS

Many people have helped make this research possible. First, it was the coöperation of the Westinghouse Electric and Manufacturing Company that made it possible to carry on the research in a large industry with a definite practical problem before me that would yield fundamental principles. This large industrial firm made it possible to have the study include a sufficiently large number of selected subjects to make the results more reliable than they would have been otherwise. In this report I wish to make special acknowledgment of the help given me by Mr. C. S. Coler, Manager of the Educational Department, and Mr. E. B. Roberts, Mr. W. E. Freeman, Mr. F. G. Kottman, and others of the Educational Department; also Mr. B. G. Lamme, Chief Engineer, and Mr. H. E. Jordan and Mr. H. B. Bassett of the Engineering Department; and Mr. S. L. Nicholson and others of the Sales Department.

I am indebted to Professor E. L. Thorndike of Columbia University for the "True-False" statements which I took from his test and incorporated in Part II of the test which I devised. Also I received many suggestions from Professor L. L. Thurstone's tests which he prepared for the Society for the Promotion of Engineering Education. I wish to acknowledge the valuable technical aid given to me by Professor W. R. Work and Mr. G. M. Porter of the Department of Electrical Engineering, Carnegie Institute of Technology.

Finally, but not least, I wish to thank Dean W. V. Bingham and Professor L. L. Thurstone of the Division of Applied Psychology, and Director C. S. Yoakum, Associate Director W. D. Scott, and the Research Fellows of the Bureau of Personnel Research, Carnegie Institute of Technology, for their suggestions and the many ways in which they have helped make this work have whatever value there is in it.

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PERSONNEL SELECTION OF GRADUATE ENGINEERS

THE DIFFERENTIATION OF APPRENTICE ENGINEERS FOR TRAINING AS SALESMEN, DESIGNERS AND EXECUTIVES OF PRODUCTION

PART I. THE PROBLEM

I. THE PRACTICAL PROBLEM

The Westinghouse Electric and Manufacturing Company each year employs about three hundred engineers who have just been graduated from technical schools and colleges. All these men have had practically the same training; but they must be differentiated and placed in different lines of engineering according to their special interests and aptitudes. The aim is not to discover which engineers are best for any particular kind of work; for a few very capable men might be best in all lines; but the aim is to discover in what line of work each engineer will function most efficiently and satisfactorily. That is, the desired end is to have each member of the organization so placed that he is able to render his greatest service to the Company by having the greatest opportunity to develop his capacities and promote himself in the line of work which he most enjoys. The practical problem is to determine methods and means for selecting and placing young engineers in the type of work which they can do best.

For selecting, differentiating, and properly assigning graduate engineers to the various phases of engineering and salesmanship, five methods or means and combinations of them are possible, namely:

1. Grades made in the technical schools;
2. The grades, try-outs, and observations secured during the year of preliminary training in the firm's educational department;

3. Rating scales;
4. Interests and desires of graduate engineers;
5. Psychological tests.

The second and fourth, interests, and observation during training are the ones emphasized at present; and in fact they are the best methods, at least until new methods are evaluated. However, these methods are not entirely satisfactory nor ideal; for the interests or choices of the men are uncertain guides and are not always identical with the needs of the company; and often the graduate engineers cannot decide themselves what work they would prefer. The process of trying out under observation during training can be done only after a certain amount of selection and differentiation has been made, and the Company has more or less committed itself in regard to its future engineers and salesmen. The training could be made more definite and intensive if it were known from the beginning, to just what line of work the graduate engineers should be assigned. Moreover, a more or less definite quota is needed for each line of work, and those men should be selected from the technical schools who would most exactly be the number required for each line of work. Finally, but not least important, the method of trying out under observation fails to reveal for what the graduate engineer is best fitted; and at best, there is often an uncertainty or question as to what work should be assigned. To meet the conditions just described, the first and second methods are analyzed, but attention is concentrated upon the development and application of the third, fourth, and fifth methods named above, that is, rating scales, survey of actual interests, and psychological tests.

II. The Psychological Problem Involved

Broadly speaking the psychological problem is one of individual differences relative to capacity for doing specific kinds of work. The previous policy was to classify and assign or place the engineers according to their interests, the practice being limited somewhat by the openings or needs in the Company and by the general impressions which the executives had of the young engineers. The big question raised was whether the men were being placed where they could function most efficiently. Were their interests a reliable criterion of their ability? This leads to the fundamental psychological questions: (1) Is marked ability in a particular line of work only general ability or intelligence directed by interest? (2) Are there different kinds of intelligence? (3) Is there one thing called general intelligence, and additional abilities which are special and which vary independently? (4) Is interest an indication of a special ability in a particular line or work? (5) Are there only special abilities, not necessarily correlating with a general average of these, which is called general intelligence? (6) Does success in a particular occupation depend upon purely intellectual ability, or are the more or less vaguely defined personal traits the more important for success? (7) When it is learned which of these factors are important, how can they be measured so as to make a prediction or a statement of the probability of success in a particular job? Summarizing these questions, we state the psychological problem as follows: To determine what mental abilities and traits are of practicable use as criteria for differentiating graduate engineers and predicting their success in six different but closely related kinds of work. This problem includes the evaluation of old methods and means and the devising of new methods and means for determining and measuring these mental abilities and traits. It is not to be expected that we should answer all the questions stated above, which have already taken years of work by the best psychologists, and will require much more work; but these questions should be recognized as pertinent in the assumptions and conclusions of this study.

This being a specific study with a definite problem in applied psychology, it does not include in its purpose and scope any historical or theoretical treatment of many general psychological problems which may be touched upon. Very few studies that have been published deal directly with this kind of problem. However, at the end of this report is appended a bibliography or list of studies which bear more or less specifically upon a problem of this nature.

PART II. THE LINES OF INVESTIGATION AND THE RESULTS

III. Occupational Descriptions and Analyses

The first important step in all personnel selection and placement is to secure adequate descriptions and analyses of the jobs to be filled. Then from these there must be prepared specifications for the persons who will most nearly meet these requirements. The specification is an interpretation of the work done on the job, in terms of capacities, skill, knowledge, and traits required to do the work. In practice the degree of specificity to which these descriptions are carried varies considerably from firm to firm and with different lines of work. In general discussions it is quite common to refer to the various *vocations,* which differentiate only the general lines of work typified by the various professions and trades. Often in employment and placement work, differentiations are made only into *occupations,* which are understood to be the specialties in the trades, such as punch press hand, lathe hand, die sinker, armature winder, etc. Strictly speaking, the *job* description is reserved for a description of a particular operation on a particular piece of material or apparatus by means of a particular tool or machine. In the Westinghouse Electric and Manufacturing Company these distinctions are made in the use of these terms by the Occupations and Rate Committee and by those in the Employment Department.

In the Westinghouse Electric and Manufacturing Company the employment and placement of the engineers is done by the Educational Department. Each spring this department selects between two and three hundred engineers from the senior classes of the technical colleges; and after giving them a year of graduate training in the Educational Department at the central plant in East Pittsburgh, it places these men in the various lines of work in the organization. Before it was possible to choose any certain engineers as better fitted for certain lines of work, it was necessary to know what was expected of these engineers in each line of work. As there were not on record any descriptions or specifications of the work done by the engineers in the various departments, this information had to be gotten first. The descriptions of the lines of work were obtained through the Educational Department.

After conferences with some of the executives who could tell most about the various lines of work, a description and outline of the nature of the occupational description desired was given to the Educational Department. Under the supervision of the Educational Department the occupational descriptions were prepared by the heads of the various sections in each of the departments. These were elaborated further by means of conferences with various executives in which questions were asked to clear up obscure details. Finally, in this manner, a conception of each line of work was obtained, which was detailed enough for working intelligently on the problem of selection and placement.

It would be out of place here to give an exhaustive description of each job or line of work in each section of each department. Moreover, such detailed descriptions are not necessary for understanding the problem that is before us. The complete occupational descriptions are on file with the Division of Applied Psychology, Carnegie Institute of Technology, and are available for those who wish to examine them. It is sufficient here to have a description of the main classes of engineering work. In actual work upon the problem, only four classes of engineers are considered, namely: (1) research workers and design engineers; (2) general or all other engineers in the engineering department; (3) operating, service, and works management engineers; (4) sales engineers. This was found practicable because nearly all the engineers were graduates of technical colleges and had received essentially the same technical training. Moreover, this process of being admitted to the technical colleges and of being graduated from them, had been highly selective so that any differentiation among the men was possible only by comparatively fine discrimination. In fact, the one real differentiation that was consistently kept in mind in all this study was that between the engineers going into the sales department and all other engineers. This might be qualified or rather more definitely stated by explaining that the design engineers were also differentiated from the other engineers, and being considered as representing the purest type of engineer, they were also considered as at the opposite extreme from the sales engineer when the differences were looked at as quantitative or linear in nature. The descriptions of these lines of work are given with particular attention to those lines considered to be most clearly differentiated. Combined with these descriptions are given the specifications for the kind of men considered best fitted for each particular line of work.

1. *Functional Classification of Engineers*

Within the organization, the engineers are classified according to the department and according to the class of product worked upon. Since the specifications for the kind of engineer needed depends upon the kind of work done, we must classify the engineeers according to the qualifications required to do the particular kinds of work: (a) In all the specialized engineering departments which are responsible for the engineering work on different particular lines of electrical apparatus and machinery, thus excepting the General Engineering Department and the Testing Department, there must be design engineering. This calls for engineering of the purest and highest type. With this type of engineering is also classed the research worker in the Research Department. (b) All the other engineers of the engineering departments are to be considered as doing a second type of work. This work is engineering; but it is not to be considered as calling for as great mathematical and technical ability and as much originality in that line as is needed by the design engineer. (c) The third class includes the engineers in Factory Management, the Service Department, and Operating. The work of these engineers brings them, to a larger extent, in contact with other people outside the organization and also with those inside the organization. Their work requires more executive ability than the work done by the other groups of engineers. (d) The fourth class is that composed of Sales Engineers. These men are primarily engineers as well as salesmen; for to get and keep the good-will and confidence of the customers, they must act as consulting engineers and give reliable technical advice to the customer or prospective customer. However, the successful engineer doing the work in the sales department must have a commercial sense and an ability to meet and successfully negotiate with other people, that differentiates him from the other engineers.

IV. Criteria of Success of Engineers

Closely allied and of equal importance with a definite knowledge of the jobs to be filled, are criteria of success of men in those jobs. Methods of selection and placement cannot be developed or improved upon unless it is possible to know when better results are obtained. The best criteria are objective measures, such as records of production; but it is seldom possible to obtain facts on such objective measures that are comparable. The work of sales engineers and of design engineers is such that it cannot be measured by the product finished. Although records of sales may be kept, many other factors enter into the value of a sales engineer to the company. The professional consulting service which the engineer gives to the customer, and the good-will secured in return, cannot be measured in that way. Also, a design engineer may spend all his time for a year or more on one machine or piece of apparatus; but if he gives the piece of apparatus an original design or makes it in the nature of an invention, his work is scarcely measurable. However, it is necessary to make use of the best criteria available.

The year spent in the Educational Department can be considered as one phase of the engineer's work. Therefore, grades and ratings on their success there are some criteria. Furthermore, the executives and instructors of that department come to know intimately all the student engineers during the year of training. To give some definite data against which tests and other ratings might be checked, the Educational Department was asked to rank the student engineers in the order of their general intelligence. General intelligence was defined for them as "the ability to analyze a problem, grasp the point, and deal with a new situation." Two men who both supervise the work of the engineers and instruct them, worked together as a committee to rate the student engineers. They first classified the men into five groups according to their general intelligence, as defined. Then they ranked the men in each group in the order of their estimated intelligence. By combining the groups, with the highest rated group first, a ranking of all the engineers was secured.

Further checks on the reliability of ratings, test scores, and these grades were possible by intercorrelations. Although none of these were absolute measures of success, it was reasonable to assume that high intercorrelations between different kinds of measures, such as between grades and tests, or between estimates and grades would show that there was a certain consistency in the measures that correlated highly with other measures, and that there was no cause to believe that they were unreliable.

V. Evaluation of Technical School Grades

The representatives of the Company, in selecting engineers graduating from the technical schools, did not consider primarily the grades received by the engineers in their college courses. They interviewed the seniors for twenty or thirty minutes, and then later inquired about the man's grades in general. However, the grades were not considered as an absolute index of a man. Leadership and participation in extra-academic activities were considered as important. It is not always easy to obtain the grades in such a way that extensive and consistent use can be made of them. I thought that probably they would show something of the technical training and ability of the men, but that many qualities making for success in engineering and salesmanship were probably not to be inferred from such grades. However, a scientific investigation of this sort would not ignore them. Moreover, a study of these grades might give some light on the significance of grades given in the Company's training courses. Accordingly, I made a study of the grades which graduate engineers received in the technical schools. Many difficulties were encountered in attempting to deal with technical school grades statistically and to derive reliable conclusions.

Transmutation and Tabulation of Technical School Grades.— A letter explaining the nature of this study and the purpose in requesting the grades was sent to over sixty different technical schools to secure the grades of 116 students. Transcripts of grades for 94 students were received. No two schools used the same form on which to record the grades; and there were at least seven distinctly different systems of grading with several variations of each system. The grades of men from different schools had to be made comparable. There were not enough men from any one school to make it possible to transmute their grades into standard deviations, so another method was adopted. The range of possible grades between the just passing grade and the highest possible grade, was learned either from the college catalogue or from the key on the transcript of grades. The median point on that scale was estimated and called the average grade. All such average grades were given a marking or value of 2. Grades above average were given a value of 3; and grades below average were given a value of 1. Grades below passing were given a value of 0; and exceptionally high grades in a subject, shown to be reliable by more than one highest marking on that subject, were given a value of 4. The method of transmutation of the grades can be shown by the following table which gives some comparable values.

TABLE I.

Transmutation of Technical School Grades into Common Values.

Common Values into which Grades are Transmuted.	0	1	2	3	4
System using per cents..	-69	70-79	80-89	90-97	98-100
System using letters.....	E	D	C	B	A
System using passing marks	F	P—	P	P+	All P+
System using descriptive terms	Fail	Poor	Good	Superior	Excellent
System using merits	Fail	Pass with low mark	Pass	Merit	Honor
System using points....	0-.9	1.0-1.9	2.0-2.9	3.0-3.7	3.8-4.0
System using class rank..	10% of class	20% of class	40% of class	20% of class	10% of class

In transmuting grades from institutions with high standards and strict grading systems, the evaluations were made higher than with institutions known to be below the average standing in the requirements it made of its students. Altogether, the transmutation was coarse as a statistical method; but it was the best that could be done with the data available; and it is considered sufficiently reliable to give significant indications.

All the subjects studied by the engineers were classified under five headings or general subjects, namely,—Languages, including English and foreign languages; Mathematics and Science, including mechanics, physics, chemistry, and all special phases of these exact and theoretical sciences; Shop; Engineering, including all kinds of engineering, but chiefly electrical and some mechanical; and all Academic subjects, which is, in the case of engineers, only history and economics.

Comparison of Technical School Grades with Other Criteria.—The first question to raise about the grades is in regard to their relation to success in industry or practical work. These engineers had not yet been in full-time work, but their year of work in the Educational Department and in the shop under the direction of that department, could be considered as one form of practical work in which success is to be determined. The estimates made by the committee of the Educational Department, explained under the title, "Criteria of Success," might be considered as one rating of success in the Educational Department. Grades given in the Educational Department classes, and grades given by the foremen on the shop work, can be considered as another check. Ratings on various qualities, explained in a section later, could be considered as the success of the men in impressing the foremen with their ability, and might be related to school grades. Also, the correlation between technical school grades and the ratings of the men made by the representatives of the Educational Department at the time of the employment interview, might be some measure of the extent to which the two measure the same qualities. Finally, a positive correlation between mental alertness or general intelligence test and college grades would be at least some evidence that school grades were some indication of what is measured by tests as general intelligence or mental ability. The correlations between technical school grades and the various other measures or criteria are as shown in Table II.

TABLE II.

Correlations of Technical School Grades with Other Measures.

	No. of cases	Correlation (r)
Technical school grades with estimated intelligence, committee's rating	88	.0
Technical school grades with educational department class grades	60	.0
Technical school grades with foremen's shop grades	62	.0
Technical school grades with foremen's ratings on traits	85	.0
Technical school grades with ratings at interview for employment	21	+.22
Technical school grades with Bureau Test VI	56	+.37
Grades in languages with foremen's ratings on traits	59	.0
Grades in mathematics with foremen's ratings on traits	72	.0
Grades in shop with foremen's ratings on traits	31	.0
Grades in engineering with foremen's ratings on traits	66	.0
Grades in academic subjects with foremen's ratings on traits	44	.0
Grades in languages with Bureau Test VI	43	.0
Grades in mathematics with Bureau Test VI	54	+.34
Grades in shop with Bureau Test VI	24	+.67
Grades in engineering with Bureau Test VI	53	+.26
Grades in academic subjects with Bureau Test VI	35	.0

The correlation coefficients between technical school grades and other criteria, particularly the Company's Educational Department class grades, shop grades, and shop ratings, might be taken to indicate that the technical school grades are unreliable. However, I do not believe that this conclusion is justified. Rather, I believe that the shop and class grades, and the ratings are unreliable, or are largely the cause for the lack of correlation. The cause for this belief will be shown later in this report.

The composite of technical school grades shows a significant correlation with intelligence test scores. Doubtless the correlations would be higher if the grades were not from so many different schools with different standards. I believe that in any particular school, an average or composite of the grades received by each student would rank the students in general ability as well as any measure; but the standards of work and the methods of grading are so incomparable in different schools that they can not be used by the employer to compare men from different schools. A standardized psychological test would show the same thing in much more reliable and usable form. That is, a general intelligence test given to a group of engineers selected from sixty different technical schools would give a more reliable ranking of the men according to their ability than a comparison of grades from these different schools; and the ranking could be obtained much easier by a test than by an attempt to transmute various systems of grades into a common scale.

The intercorrelations of the grades in the various subjects is shown in Table III. As might be expected, the correlation between closely related subjects, such as Mathematics and Engineering, ($r = +.57$) is greater than between what are usually considered less closely related subjects, such as Academic Subjects and Shop ($r = +.30$). There might be some *a priori* question about the correlations between Shop and Mathematics or between Shop and Engineering, but the correlations are shown to be comparatively high, being ($r = +.61$) ($r = +.42$) respectively. Shop grades correlate higher with Bureau Test VI scores than any other technical school subjects do; but the number of cases is so small that the large probable error makes the correlation coefficient highly unreliable. However, it will be seen later that the design engineers, who are picked men and are supposed to be the most capable men in pure mathematics and engineering, have the highest grades in Shop, and are differentiated more widely from the other engineers by the average of their grades in Shop. It seems that the grades that a man receives in his shop work in the technical schools is significant of his special engineering aptitude, and even of his general mental capacity.

For differentiating the engineers for the different lines of work which they are to do, I thought that grades in different subjects might be significant. The average grade in each main subject for each class of engineers was computed, and curves plotted to show the relation of one group of engineers to the others. (See Diagram 1.) The design engineers are above the

Table III.

Intercorrelations of Technical School Subjects.

Subjects	of cases Number	(r) Correlation
Languages with mathematics	77	+.38
Languages with shop	35	+.37
Languages with engineering	69	+.55
Languages with academic subjects	53	+.30
Mathematics with shop	43	+.61
Mathematics with engineering	85	+.57
Mathematics with academic subjects	57	+.42
Shop with engineering	63	+.42
Shop with academic subjects	21	+.30
Engineering with academic subjects	54	+.35

other engineers in every subject, indicating that they were superior students in the technical schools. The curves of the general engineers and of the operating, service, and works management engineers run comparatively close together, the average of one group in a subject rising or falling with the average of the other group of engineers. The average of the sales engineers varies inversely with the averages of the general and the operating, works, and service engineers. The significant feature of the averages, however, is that the design engineers are very much higher in all subjects, except the academic subjects, composed chiefly of economics, while in this subject the sales engineers have almost as high an average, although the general or all-around ability of the design engineers is evidently higher. The man who has been selected for other reasons as promising of becoming a good sales engineer, is the one who had special ability in the social sciences.

VI. Evaluation of Grades and Ratings Given During Training in the Educational Department of the Industrial Firm

As soon as the engineers, usually just graduated from the technical school, enter the employ of the Company, they begin the year of training in the Educational Department. Practically all the engineers spend the first two months taking the same courses and doing the same work. In addition to class work, they work about a month in one department of the shop and then pass on to another kind of work so as to become familiar

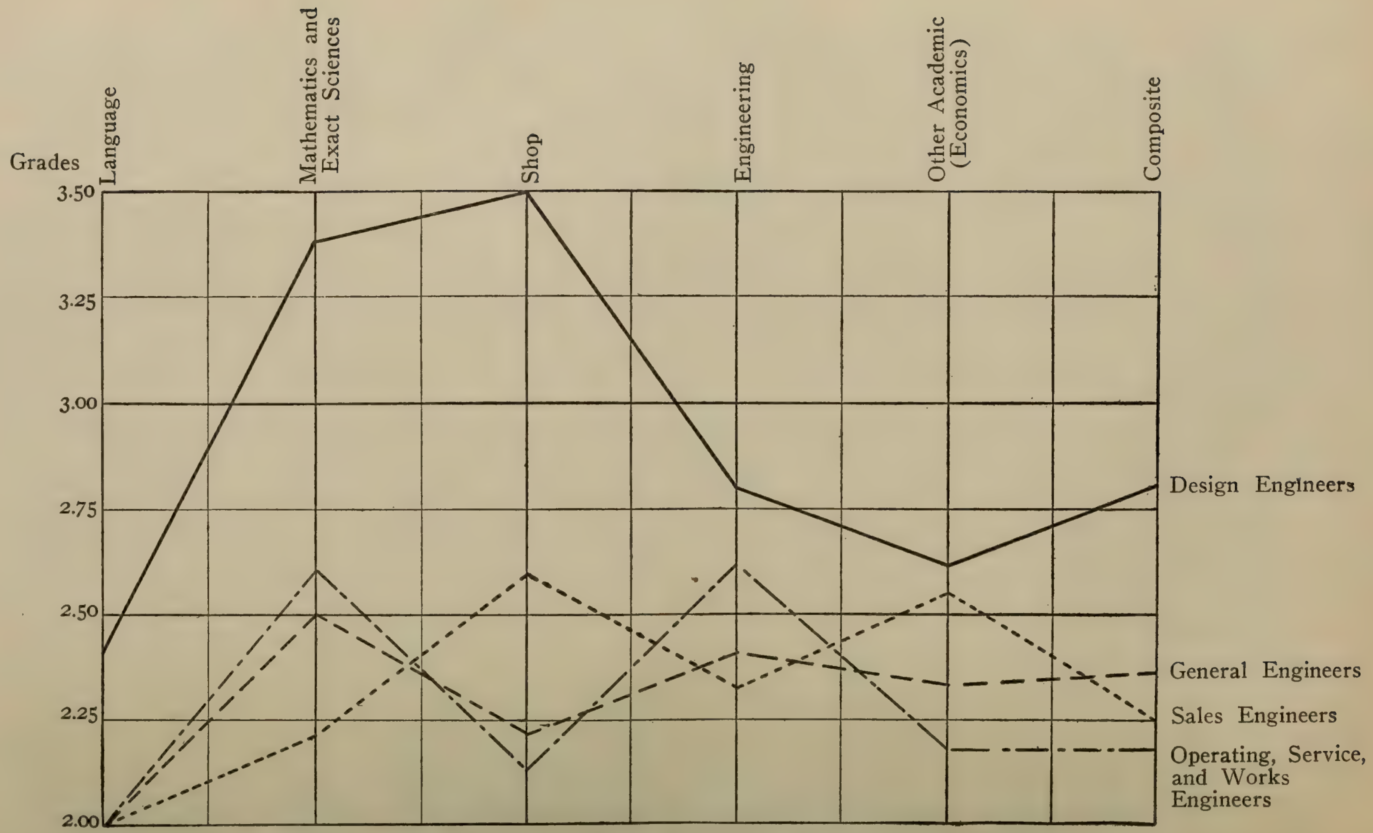

Diagram 1. Averages of Technical School Grades for Each Group of Engineers.

with as many phases of the manufacturing process as possible. To make the absorption of the men into the shop possible and efficient, the men have to be divided into many groups and sent into many different sections, but the work for all is very similar at first. At the end of two months, however, there is begun the work of segregating the men into groups according to the line of work that they will do permanently. That is, the sales engineers and the design engineers, works management engineers, general engineers, etc., are picked out. This process of transferring the men from one department to another and of determining to what line of work each will be eventually assigned, continues until the end of the sixth month. Beginning with the sixth month a Sales School and a Design School are started; and the engineers begin specialized training for their future work.

From the time that the engineers enter the Educational Department, extensive records of their work are kept. Most of the men are first assigned to industrial motor winding and are graded on that work, both in the classes and in the actual work in the shop. In this work, the correlation between the shop grades and the class grades was $r = +.19$, for 76 cases. The grades for any one group of engineers plotted separately showed no different correlations. This low correlation shows the disagreement of the impressions received by different people, and the unreliability of opinions concerning traits in people, particularly when the judgment must be made only after a short period of observation of the subject's work. The curves in Diagram 2, show that the design engineers receive the highest grades in the shops. This agrees with the fact that they received the highest grades in Shop in the technical school grades.

In addition to the grades in the different subjects or kinds of work, there come from the foremen over each department, ratings on various traits of the engineers working temporarily under these foremen. These ratings are on ten different traits or characteristics; and they are made in terms of A, B, and C. The names of the ten traits are reliability, industry, initiative, tact, attitude, analytical ability, aptitude, enthusiasm, personality, decision.

Since the men are transferred each month and rated by different foremen, several ratings in each trait are recorded. By combining these ratings a more discriminating rating on each man of the group being studied was obtained. That is, the values A, B, and C were transmuted into the values 2, 1, and 0, respectively; and by combining and averaging these ratings, fractional values between these integers were obtained, such as 0.8 or 1.3 or 1.7 as a man's average rating. Correlations of these shop ratings with other data on the men, are given in Table IV.

TABLE IV.

Correlations of Shop Ratings with Other Criteria.

Subjects	Number of cases	Correlation (r)
Shop ratings with estimated intelligence, committee's rating	95	.0
Shop ratings on analytical ability with estimated intelligence, committee's rating	94	.0
Shop ratings with Bureau Test VI scores	58	.0
Shop ratings on analytical ability with Bureau Test VI scores	56	.0
Shop ratings with ratings at interview for employment	27	.0
Shop ratings on analytical ability with ratings on intelligence at interview for employment	26	.0
Shop ratings on personality with ratings on personal qualities at employment interview	27	+.25
Shop grades with shop ratings	74	.0

From these correlations we conclude that the ratings made by the foremen on the men working under them only one month, are very unreliable, and really indicate nothing. Doubtless, this unreliability cannot all be charged to the inability of the foremen to judge the men on some of these traits; but the method of rating, of recording these ratings, and of combining ratings by different foremen, makes them incomparable and unreliable. In the shop and the Educational Department, the interpretations of analytical ability and of aptitude are practically the same as that which is called general intelligence by the psychologists. The ratings on analytical ability were correlated with estimated intelligence and with test scores in the hope that a significant positive correlation would be found, but there was none. One exception to the lack of positive correlation is the small correlation between personality as judged by foremen and personal qualities as judged by the representatives of the company who rated the men at the interview for employment. It seems reasonable to expect such a positive correlation; for it is doubtless the general personality which influences both the interviewer's and the foreman's rating on a man in most of the traits, in much the same way.

TABLE V.

Some Intercorrelations of Ratings by Foremen on Traits of Engineers.

	Number of cases	Correlation (r)
Reliability with industry	117	+.66
Initiative with tact	113	+.66
Initiative with enthusiasm	107	+.42
Analytical ability with aptitude	102	+.72
Analytical ability with personality	104	+.26
Enthusiasm with personality	106	+.57

Correlations between the ratings on some of the traits were computed. The highest correlation found is between analytical ability and aptitude, + .72, which seems *a priori* reasonable. The next highest correlation is ($r = +.66$) between reliability and industry, which might be expected; but there is the same correlation between tact and initiative, two traits which *a priori* we should judge would tend to be found in somewhat opposite types of individuals. The lowest correlation is between analytical ability and personality, which does not seem unreasonable.

To discover whether the ratings on the ten different traits could be of any value in differentiating the engineers, the average of the ratings on each trait for each group was computed. These averages are shown in Diagram 2. The curves tend to follow each other very closely. Also, it was found in most of the ratings that if a man was rated high in one trait, he was rated comparatively high in another. Personality and enthusiasm differentiate the groups most widely. Frequency column diagrams, Diagrams 3, 4, 5, and 6, show that the ratings in these two traits and in tact and initiative, tended to separate the sales engineers, and the work management engineers from the other engineers. By combining the ratings in these four traits we get a very definite differentiation of the four groups of engineers. See Diagram 2. It seems evident that people on coming in con-

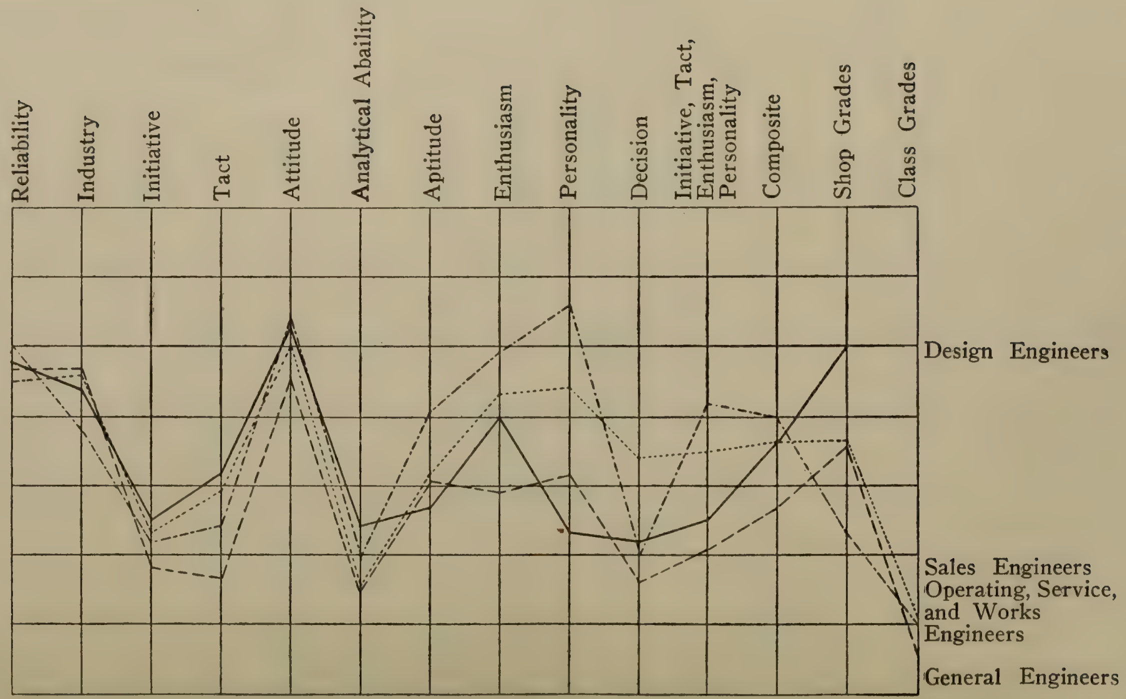

Diagram 2. Averages of Foremen's Ratings and Grades and of Instructors' Class Grades for Each Group of Engineers.

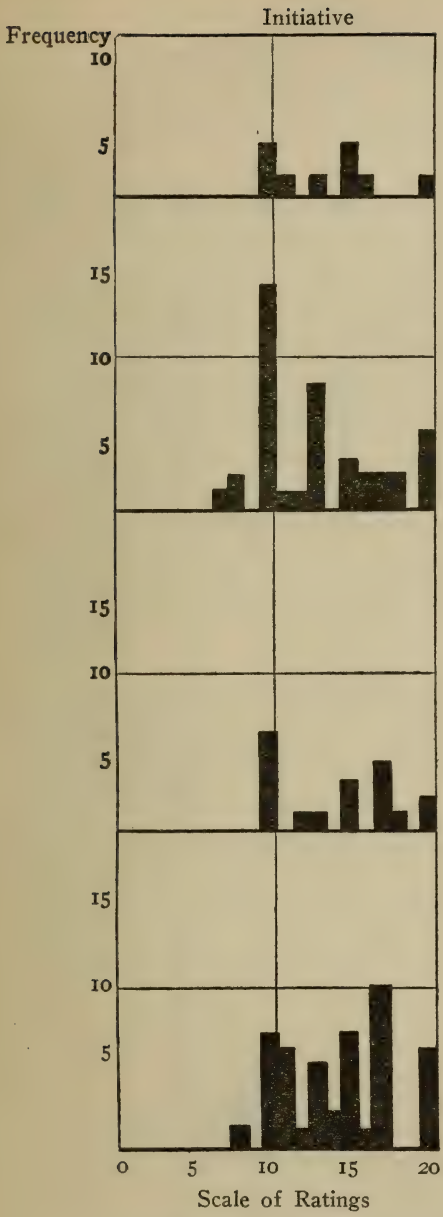

Diagram 3. Ratings on Initiative by Foremen of Student Engineers Classified by Occupation.

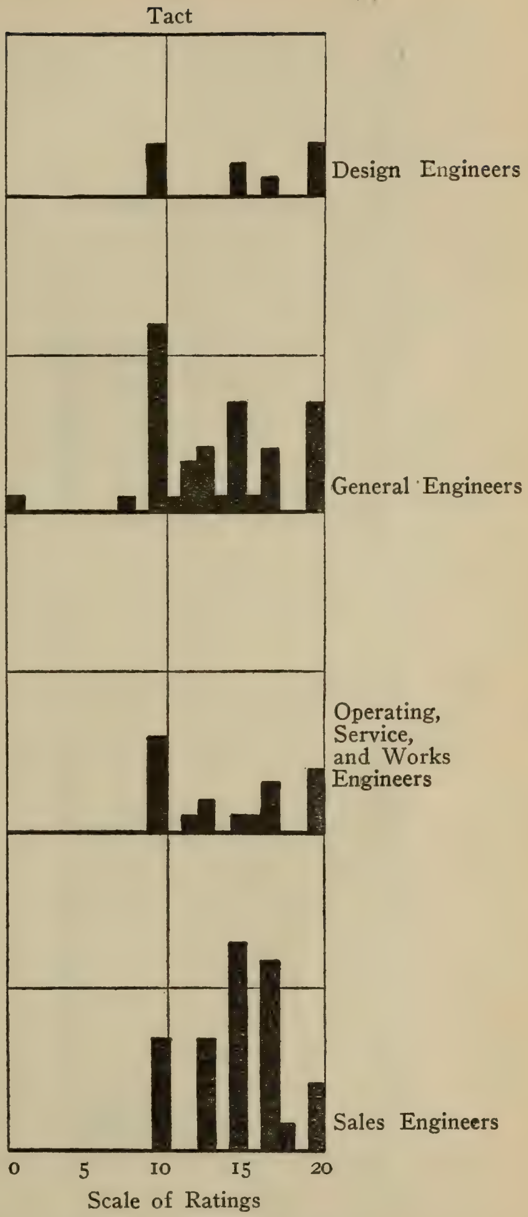

Diagram 4. Ratings on Tact by Foremen of Student Engineers Classified by Occupation.

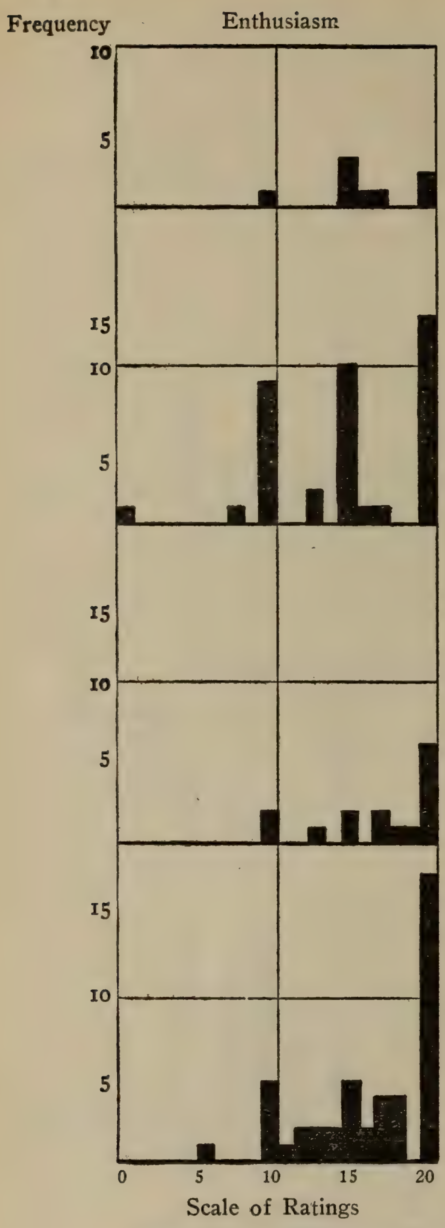

Diagram 5. Ratings on Enthusiasm by Foremen of Student Engineers Classified by Occupation.

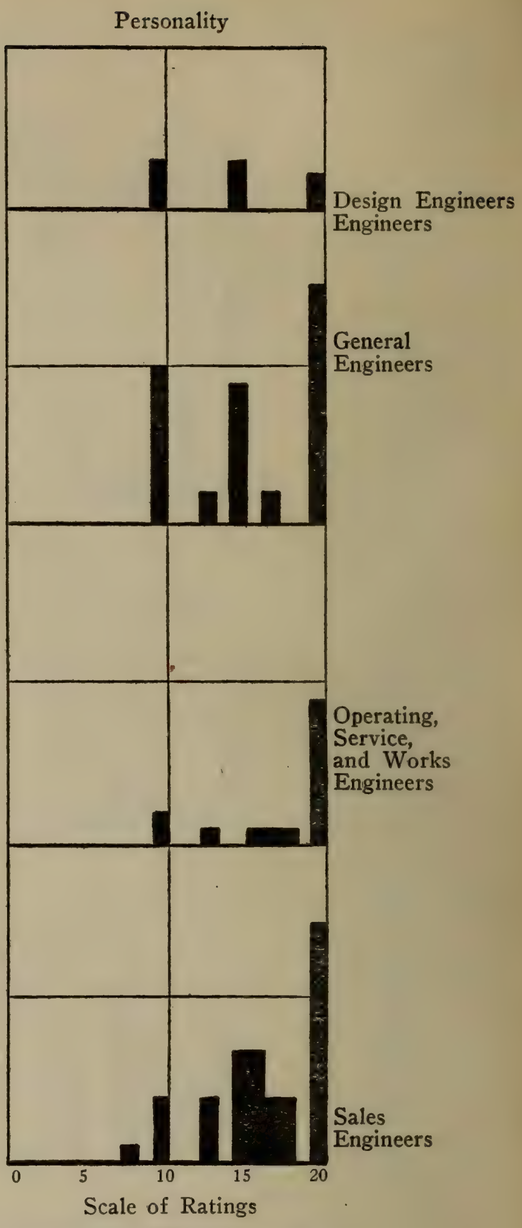

Diagram 6. Ratings on Personality by Foremen of Student Engineers Classified by Occupation.

tact with the different groups of engineers sense a difference in the personal traits of these men; but definite analysis and measurement of this difference is difficult in any particular individual.

VII. A Study of Rating Scales

For differentiating sales engineers from other engineers, it is probably true that the personal qualities aside from intelligence are more important. This has been recognized in the attempt to estimate these qualities as a whole without a rating scale when a man was being considered for any particular work. There are at present no psychological tests for measuring these qualities, but there are refined methods of making estimates or ratings. The rating scale is a tool or means for carrying out such a more accurate method. Its value as a measure of various traits depends upon the standards which it sets up as measuring rods, and its accuracy depends upon the definiteness of these standards.

1. *Principles of a Rating Scale*

Employers have always tried to estimate the value of a man as a whole, considering his qualities altogether without the use of a rating scale. Great differences in the estimates made by different persons on the same man have shown this to be an uncertain method. The man's qualities must be separated and rated by themselves; for if they are not, the estimator is likely to let his prejudices consider only one prominent quality and let them bias his judgment so as to neglect all other qualities. For example, a foreman or supervisor may have an intense dislike for one of his workers because the worker has a disfigured face, and unconsciously the foreman overlooks the man's other good qualities. However, when the rating scale calls for a consideration of these qualities separately, he is forced to realize that the worker may be intelligent, industrious, skillful, and coöperative. After the foreman is led to face the facts in this way, he must admit that, after all, the man has good points that are valuable in a workman. On the other hand, the foreman may have to admit that he has been overlooking another workman's laziness and lack of skill because this man was always good-natured and sociable. Moreover, the fact that these ratings must be signed and given in black and white to a superior who can check them, leads the foreman to consider sources of inefficiency in his workers. It also makes him more careful and fair-minded in his judgments of his men.

We can then lay down as the first principle of the rating scale that: (1) Instead of trying to estimate a person's ability as a whole for doing any particular work, this ability is analyzed into component essential abilities or traits, and each trait is rated independently of the others. The traits selected should be the most important for success in the particular situation. It is much better to have a few traits that are really essential and critical for a worker's success than to have ratings on many traits, some of which are relatively unimportant. That is, it is much better to concentrate on a few important qualities and have ratings on these made and really used than to have a system so elaborate that it breaks down from its own size and complexity. The traits included in the rating scales discussed here were selected for rating men under certain conditions for a definite purpose. Anyone using this scale would have to consider these traits for their particular purpose in the light of the principles stated here.

The reliability of a rating scale as a measure of various traits depends upon the standards, particularly the definiteness of the standards which it sets up as measuring rods. Therefore, other principles for making an accurate rating scale are to be observed; and the next principle is: (2) the different traits determined upon must be really different and as distinct from each other as possible. They must be supplementary to each other with the minimum of indefiniteness and overlapping.

(3) For rating a person in any trait, the person doing the rating must be acquainted with the one to be rated, and have more or less dependable facts for making a decision. When an employee asks for a promotion or transfer, the employment manager cannot rate the employe in *coöperation* or in *industry;* but the worker's previous foreman probably could. On the other hand the employment manager might be a better judge of the

applicant's *appearance and manner* in considering him for transfer to the office or some place where he would meet the public.

(4) The traits must be as sharply defined as possible so that different people doing the rating will rate the same trait. In naming and defining traits, use terms which are more or less common and have, as nearly as possible, universally the same meanings accepted by everybody and the minimum chances of ambiguity and misunderstanding.

(5) For rating an individual in a trait, the basis of comparison used as a scale should be as concrete and as familiar as possible. To provide this condition, the person to be rated is compared in regard to a particular trait with other well-known persons who differ in the extent to which they have that particular trait. That is, a foreman, in rating a man, should compare him with men who are doing the same kind of work under similar circumstances; and the foreman must be well acquainted with the traits and qualifications of the men.

(6) Where more than one individual is to be rated in more than one trait, more comparable results are obtained by rating all individuals in one trait before rating any of the individuals in any other trait.

(7) More reliable results are obtained by having a person rated by more than one person, ratings by three persons being recommended if it is possible to get them. These ratings should be made independently and then averaged. A revision of one rating by another person is not so accurate as a combination of two ratings made separately.

2. *Evaluation of the Rating Scale Used, Entitled, "Rating by Interviewer"*

With the above principles in mind, a study was made of the results of the scale already in use by the Company, which is entitled *Rating by Interviewer* (p. 24). The purpose was to check the value of such a scale and the particular selection of traits. The scale was used with only thirty-one students, but the number is sufficient to give results that are significant, though by no means final. Table VI. shows the correlations between the

RATING BY INTERVIEWER

THIS SIDE NOT TO BE WRITTEN UPON BY APPLICANT

I. Physical qualities—Physique, bearing, neatness, voice, energy, endurance. (Consider how he impresses men in the above respects.)	Highest	20	Remarks
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
II. Intelligence—Accuracy, ease in learning, ability to grasp the point quickly, to express himself clearly, and to estimate a new situation.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
III. Leadership — Initiative, force, decisiveness, tact, helpfulness, ability to inspire men and to win their loyalty and cooperation.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
IV. Personal qualities—Industry, dependability, loyalty, readiness to shoulder responsibility for his own acts, freedom from conceit and selfishness, readiness and ability to cooperate, and charm of personality, breadth of conceptions.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	
V. General Value to the Company—Special talent (commercial, mechanical, mathematical, executive), gets results, works well in an organization. Special interest in W. E. & M. Co. Previous training and experience. Will develop.	Highest	20	
	High	16	
	Average	12	
	Low	8	
	Lowest	4	

Recommendations of Professors and Instructors—

REPORT OF INTERVIEWER

1. General impressions ____________________
2. Work best suited for ____________________
3. Acceptance (write Yes or No) ____________________
4. Next action promised by interviewer ____________________

Signed ____________________ Date ____________________

Interviewer

original interview ratings, the tests, and the ratings made by the Educational Department committee one year later. Also the relation between each trait and the total of ratings on each trait, and the intercorrelations between traits is shown. All correlations are positive.

TABLE VI.

Correlations of Ratings by Interviewers with Other Criteria.

	Number of cases	Correlation (r)
Interviewers' composite ratings with estimated intelligence, committee's rating	31	+.65
Interviewers' composite ratings with Bureau Test VI scores	18	+.58
Interviewers' ratings of intelligence with Bureau Test VI scores	18	+.57
Interviewers' ratings of intelligence with estimated intelligence, committee's rating	31	+.22
Interviewers' composite ratings with shop ratings	27	.0
Interviewers' ratings of intelligence with shop ratings on analytical ability	26	.0
Interviewers' ratings of personal qualities with shop ratings on personality	27	+.25
Interviewers' composite ratings with technical school grades	21	+.22
Interviewers' composite ratings with their ratings of leadership	32	+.80
Interviewers' composite ratings with their ratings of personal qualities	32	+.79
Interviewers' composite ratings with their ratings of physical qualities	32	+.73
Interviewers' composite ratings with their ratings of general value to company	32	+.68
Interviewers' composite ratings with their ratings of intelligence	32	+.68
Personal qualities with general value to company	32	+.67
Personal qualities with leadership	32	+.59
Intelligence with general value to the company	32	+.48
Leadership with general value to the company	32	+.47
Leadership with physical qualities	32	+.46
Personal qualities with physical qualities	32	+.45
Intelligence with personal qualities	32	+.44
Physical qualities with general value to company	32	+.43
Intelligence with leadership	32	+.40
Intelligence with physical qualities	32	+.23

The interviewers' ratings of intelligence agree much better with the scores of the psychological test for intelligence, r = +.57, than they do with the committee's later estimate of intelligence, r = +.25; but since the interviewers' ratings of intelligence correlate comparatively low with their composite ratings including other qualities, r = +.68, and since the composite ratings have high correlation with the later estimate of intelligence by the committee, r = +.65, we might take these facts as evidence that qualities other than intelligence have unconsciously been included in the later ranking of the men.

The most important correlations to consider in relation to the rating scale, are those of Personal Qualities, which correlate, with General Value to the Company, r = +.67, and with Leadership, r = +.59. These correlations are entirely too high between traits which according to the best principles should be disparate traits. These high correlations are undoubtedly due to the indefinite and too inclusive definitions of these traits. Therefore I have worked to make these traits more definite and exclusive in the revised definitions or descriptions of them. The revised forms are seen in the Interviewer's Master Scale, discussed later. Some of the other traits have had the definitions slightly changed to make the same improvement toward definite unit traits which could be more accurately rated.

3. *The Revised Form of Interviewer's Rating Scale: The Interviewer's Master Scale*

Not only were these results considered in the revision, but the whole aim was to make the rating scale best adapted to select men for the particular lines of work to be done for the particular Company. From the occupational description or information that had been obtained concerning each line of work to which a graduate engineer is later assigned, I made an analysis of what qualifications or traits are essential for success in each line of work or specific occupation. The traits for each occupation were listed separately. Then to enrich this list and to be sure that no traits were omitted, comparison was made with the list of traits already being used by the Westinghouse interviewers and also with the traits considered in a rating made later in the Educational Department. Also all other available rating scales, including the Bureau Scale for Salesmen, and the Army Officer Rating Scale, were compared with the list of traits. Finally, Mann's Study of Engineering Education, and Davenport's Trait Book, which lists several hundred traits, were examined for suggestions of traits. From the final nine lists of traits (one list for each occupation), selection was made for the traits common to all lists and those which were similar were grouped under one name of an essential trait. Then selection was made of those traits which were not common and which tended to differentiate the occupations. For making the scales to be used in the first selection and employment of applicants or prospective applicants, the common and the differentiating traits were combined. For constructing the scales which were to be used later in separating the men, the differentiating traits were emphasized.

The first work in preparing rating scales was to revise the scale already in use, called the *Interviewer's Rating,* shown on page 24. As the revisions were simply in the definitions of the traits, these may be seen in the form for the *Interviewer's Master Rating Scale,* which was prepared. This Master Scale is the standard or measuring rod with which the senior engineer is compared and rated by the interviewer. The form of this is shown on page 28. The method of making and using the scale is explained in the following section.

4. *Instructions to Interviewers for Rating Senior Engineers*

Significance of the Rating Scale.

(1) The rating of a senior engineer is a numerical expression of the degree in which he possesses five qualifications considered essential in a Westinghouse engineer, namely: (I.) Physical Qualities, (II.) Intelligence, (III.) Leadership, (IV.) Social and Personal Qualities, (V.) General Value to the Company. The rating is made by comparing him in each of these respects with engineers who are now employed in the Company. Each rater makes his own scale, using the Interviewer's Master Rating Scale. Proper rating is largely dependent on the possession of an accurate Master Rating Scale. Do not start to prepare your scale until you can give at least thirty minutes to it.

INTERVIEWER'S MASTER SCALE

(To be filled out by all interviewers in committee together, for use as a standard in rating each applicant.)

Have before you the names of at least twenty-five of your engineers and salesmen with whom you all are well acquainted. Include in this list men that rank highest, lowest and intermediate in Physical Qualities; men that rank highest, lowest and intermediate in Intelligence; and similarly in Leadership, in Social and Personal Qualities, and in General Value to the Company.

I. Physical Qualities

Disregard every characteristic of each of your engineers and salesmen except their physical qualities. Consider *physique, bearing, neatness, facial expression, voice, charm of appearance and manner, energy, and endurance.* (Consider how he impresses men in such qualities.)

Highest Mr....................20
High Mr....................16
Middle Mr....................12
Low Mr.................... 8
Lowest Mr.................... 4

II. Intelligence

Consider *common sense, judgment, ability to grasp the point quickly, to express himself clearly, and to estimate a new situation.* On the basis of intelligence make a selection of five of your men as in Number I above,—highest, lowest, middle, high, low. These five need not be the same as those in Number I.

Highest Mr....................20
High Mr....................16
Middle Mr....................12
Low Mr.................... 8
Lowest Mr.................... 4

III. Leadership

Consider *force, decisiveness, enthusiasm, and ability to inspire men and to win their loyalty and cooperation.*

Highest Mr....................20
High Mr....................16
Middle Mr....................12
Low Mr.................... 8
Lowest Mr.................... 4

IV. Social and Personal Qualities

Consider *conversational ability, tact, freedom from conceit and selfishness, readiness to shoulder responsibility for own acts, readiness and ability to cooperate, sociableness, and congeniality.*

Highest Mr....................20
High Mr....................16
Middle Mr....................12
Low Mr.................... 8
Lowest Mr.................... 4

V. General Value to the Company

Consider *previous training and experience showing interest and adaptability,* (commercial, mechanical, mathematical, executive) *special interest in W. E. & M. Co. and professional attitude.*

Highest Mr....................20
High Mr....................16
Middle Mr....................12
Low Mr.................... 8
Lowest Mr.................... 4

How to Make the Master Scale.

(2) Write on small slips of paper the names of from 12 to 25 engineers who have passed through the Educational Department within the previous five years. They should be men with whom you are well acquainted, and of whose degree of success you have some definite knowledge. Include some whose qualifications are extremely poor as well as those who are highly efficient. If these

names do not include all the grades for each of the five qualifications, others may be added.

(3) Look over your names from the viewpoint of Physical Qualities only. Disregard every other characteristic of each man except the way in which he impresses men by his physique, bearing, neatness, voice, charm of appearance and manner, energy and endurance. Arrange the names on the slips of paper in order from highest to lowest on the basis of the Physical Qualities of the men. Select that engineer who surpasses all the others in this qualification and enter his name on the line marked Highest under Physical Qualities on the Interviewer's Master Scale. Then select the one who most conspicuously lacks these qualities and enter his name on the line marked Lowest. Select the man who seems about half way between the two previously selected and who represents about the general average in Physical Qualities; and enter his name on the line marked Middle. Select the engineer who is halfway between middle and highest, and enter his name on the line marked High. Select the one who ranks halfway between middle and lowest, and enter his name on the line marked Low.

(4) In the same manner make out scales for each of the other four qualifications (Intelligence, Leadership, Social and Personal Qualities, and General Value to the Company).

(5) Each engineer whose name appears on the Scale should be one who exhibits clearly and distinctly the qualification and the degree of the qualification for which he has been chosen.

(6) The names for Highest and Lowest on each section of the Scale must represent extreme cases. The names for the Middle should be that of an average engineer, halfway between extremes. High and Low should be halfway between the Middle and the extremes. An even gradation of merit is important.

(7) In making or using any section of the Scale, consider only the qualification it covers, totally disregarding all the others.

How to Use the Scale.

(8) Rate your senior student engineer for Physical Qualities first. Consider how he impresses men by his physique, bearing,

neatness, voice, charm of appearance and manner, energy, and endurance. Compare him with each of the five men in Section I. of your Master Rating Scale, and give him the number of points following the name of the man he most nearly equals. Check this number under Physical Qualities on your blank entitled Interviewer's Rating. If he falls between two men in the Scale, give him a number, accordingly, between the numbers of these two names in the Scale.

(10) Rate the engineers in a corresponding manner for each of the other four essential qualifications.

(11) In rating, make a *man-to-man comparison* of the man with the men whose names appear on your Scale—never in terms of numbers directly. *Disregard the numerical equivalent until you have made these concrete comparisons.*

(12) When rating several engineers, rate all of them on each qualification before adding the total for any one.

(13) This is not a percentage system and you should not allow yourself to fix in mind any particular number of points you think the engineer ought to get.

(14) The total rating for an engineer is the sum of the ratings you give him in the five separate qualifications.

5. *College Instructor's Rating Scale.*

There are many traits desirable in an engineer which can not be rated with any reliability from a brief interview with a senior student. However, an instructor having had the student in his classes and knowing of his college activities, could rate the man on definite objective criteria. It was thought at first that the *College Instructor's Rating Scale* (see page 31) should have entirely different traits; but in order to reduce the possibilities of confusion to the minimum and to make the combination of the ratings of the two scales easy, practically the same names of traits are used on both scales. The ratings from the Instructor's Rating Scale can be checked just to the left of the interviewer's ratings on the present form, Rating by Interviewer. However, it is *important that the interviewer make his rating independently*

COLLEGE INSTRUCTOR'S RATING SCALE

Will you please rate the student named below for the traits indicated, keeping in mind employment after graduation. Give the rating independently without consulting others. This rating sheet is to be returned to the Bureau of Recommendations without delay. Do not rate any student whom you have not had in class at least one term.

Name ....

Among the members of the average senior class in this student's COURSE AND SCHOOL, in which fifth would this student rank in each trait? Indicate the rank in each trait by placing a check (√) at the proper height in each column, grading the student as finely as you can. The traits are described as follows:

I. *Appearance and Manner.*—Consider physique, bearing, neatness, facial expression and voice. (Consider how he impresses men in such qualities.)

II. *Intelligence.*—Consider accuracy, promptness, ease of learning, ability to grasp the point quickly and to express himself clearly, and ability to estimate a new situation and to get desired results professionally.

III. *Leadership.*—Consider initiative, self-reliance, enthusiasm, tact, and ability to inspire men and to win their loyalty and cooperation.

IV. *Personal Qualities.*—Consider honesty, reliability, spirit of service, sense of responsibility for his own acts and moral stamina.

V. *Professional Interest.*—Consider industry, energy, perseverance, and conscientious application to work.

	Appearance and Manner	Intelligence	Leadership	Personal Qualities	Professional Interest
Highest Fifth					
Second Fifth					
Middle Fifth					
Fourth Fifth					
Lowest Fifth					

To aid further the Bureau of Recommendations, please indicate, if possible, THE SPECIFIC KIND OF WORK for which this student is best fitted.

....

....

In this SPECIFIC WORK how would you rate this student among the members of the average Senior Class in this student's COURSE AND SCHOOL? Indicate your opinion by a check (√) at the proper height in the column to the right.

SPECIFIC WORK

Highest Fifth: ____

Second Fifth: ____

Middle Fifth: ____

Fourth Fifth: ____

Lowest Fifth: ____

(Use the other side of this sheet for remarks concerning the student.)

and before he sees the instructor's ratings or copies them on his sheet. Then an average of the two can be made.

The traits to be rated are not defined the same on the two scales. They should be rated from two different viewpoints, namely from what the instructor's acquaintance and observation reveals to be the actual rating of the trait, and from the first impression which the individual gives other people regarding the trait, as shown by the interviewer's rating. With the background and viewpoint of the instructor differing from that of the interviewer, the ratings will supplement and balance or check each other. Professional interest or industry and professional ability can be judged better by the college instructor; but General Value to the Company can be judged better by the Company representative.

The instructor cannot be expected to prepare a scale, so he is asked to rate the student in terms of fifths of the average senior class. The interviewers, however, should prepare an Interviewer's Master Rating Scale, and by mental comparison of students with the men named on this scale, that is, a man-to-man comparison, a rating can be given to that student for each trait, and then be entered on the form, *Rating by Interviewer.*

6. *Shop and Class Rating Scale*

The unreliability of the shop ratings made by the foremen, and of the class and shop grades, has already been discussed in Chapter VII, entitled "Evaluation of Grades and Ratings Given During Training in the Educational Department of the Industrial Firm." It was stated there that the causes of this unreliability were evidently due to the lack of adequate definitions of the traits, to the lack of common understanding by the foremen of the meaning of the names of the traits, to the lack of a standard, scale, or measuring rod with which to compare the persons being rated, and to the arbitrary method of recording and reporting the ratings. In order to obviate or at least minimize these causes of unreliability of the ratings, the *Shop and Class Rating Scale* was prepared. It is intended that each foreman and instructor shall rate each student engineer under them once each

SHOP AND CLASS RATING SCALE

Name .... Section................

Rate the man named above in the traits indicated. The traits are defined and described on the other side of this sheet.

Among the Graduate Engineers whom you have known in this particular work that you have charge of, in which fifth,—highest, second, middle, fourth, or lowest, should this man rank in each trait? Indicate the rank in each trait by placing a check (√) at the proper height in each column, grading the man as carefully as you can.

	Intelligence	Co-operation	Industry	Leadership
Highest Fifth				
Second Fifth				
Middle Fifth				
Fourth Fifth				
Lowest Fifth				

In what work does this man excel?..

....

In what is he deficient?..

....

Signed .... Date ....

Note:—Send to the Educational Department.

DEFINITIONS OF TRAITS OR QUALITIES TO BE TREATED

I. Intelligence.—Consider aptitude, ability to learn, common-sense, judgment, and ability to grasp the point, to express himself clearly, and to deal with a new situation.

II. Cooperation.—Consider tact, courtesy, fair-mindedness, sociability, and ability to get along with other men and to fit into the organization.

III. Industry.—Consider energy, perseverance, conscientious application, reliability, interest, enthusiasm, and loyalty.

IV. Leadership.—Consider initiative, aggressiveness, force, decisiveness, and ability to influence men and win their loyalty and cooperation.

month on this *Shop and Class Rating Scale.* The ratings are to be sent to the Educational Department office, where they are to be combined with the other data on the student engineers.

For differentiating the sales engineers from the other engineers certain traits considered essential for sales engineering ability can be selected and the total rating on these traits for each graduate engineer will show his probable aptitude for sales engineering. To take advantage of data previously obtained, ratings on certain traits which differentiate the graduate engineers, for example traits desired in a salesman, might be selected from the other rating scales and combined with these. For example, ratings on leadership, social and personal qualities, and physical qualities might be taken from the *Interviewer's Rating Scale* and from the College *Instructor's Rating Scale.*

VIII. SURVEY AND EVALUATION OF INTERESTS AS CRITERIA FOR VOCATIONAL PLACEMENT

1. *The Significance of Interests*

The technical school grades, the grades and ratings on the work of the men during training in the Educational Department, and the results of the tests discussed in the next section, indicate that the engineer cannot be differentiated for the different kinds of work by general intelligence or mental alertness. Men with equal mental ability are found in all the lines of work. Success of a certain person in a particular line of work is evidently due to general intelligence or mental ability directed in a particular line by interests. However, it is probably true that the interests are based on a particular ability or group of abilities which makes activity and achievement in a particular line of work possible and interesting. Leaving the question of general intelligence and particular abilities to be discussed in the next section, we consider here the interests themselves without raising the question of what causes them.

After the man has a definite strong interest in any line of work or activity, this interest, motivation, or whatever it may be, should be taken advantage of. It is difficult to discover just what the interests are, and often the graduate student engineers cannot decide themselves what work they should prefer. In order to make possible the planning and direction of their training, the custom has been to ask them to indicate their choice of work at the end of two months' work in the Westinghouse Company, during which time they have been doing various kinds of work in the shop under the supervision of the Educational Department. To help them make this choice, and to help the executives know more definitely what this choice is, the form, *Record of Interests,* which is a kind of rating scale, has been prepared.

2. *Method of Using the Record of Interests*

With the exception of Section II., entitled Choice of Other Occupations, the whole of the Record of Interests blank may appear to add nothing new to the ordinary questions often asked when attempting to place a man. Nevertheless, there is a definite attempt to get these facts tabulated in usable form. Each class of information or facts concerning the man is considered separately, and a definite unmixed judgment is made on that phase of the man's interests and qualifications. Thus the *Record of Interests* is really a rating scale of interests. The judgments

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RECORD OF INTERESTS

Prepared by B. V. Moore, Research Fellow, Expressly for the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

To the Graduate Student Engineer:

Answer the questions, and fill in the blanks as accurately as you can. None of your statements here commit you to any particular assignment. This record enables us to help you find the most suitable position in the Westinghouse organization.

I. PREVIOUS VOCATIONAL INTERESTS

1. In your college work which type of work or subjects interested you most? Rank the types of work below in order of preference, numbering the best liked (1), the next best (2), and so on to the least liked, which you number (9).

( ) English
( ) Economics
( ) History
( ) Field Work
( ) Shop Work
( ) Drawing or Draft'g
( ) Testing
( ) Laboratory
( ) Mathematics

2. Did you ever construct or build any mechanical or electrical toy, apparatus, or machines of any kind before you entered college?

( ) No ( ) Yes

3. What were the things you made?..............................

....

4. Did you make these things chiefly because you wanted the things themselves or because you enjoyed making them?

( ) Wanted the things. ( ) Enjoyed making them.

5. In making the toy, apparatus, or machine, did you make it like another, or did you design it yourself?

( ) Made it like another. ( ) Designed it myself.

6. Did you ever work as a salesman or clerk in a store, sell in a house to house canvass, or work as a salesman in any way?

( ) Yes ( ) No

7. What do you consider to be the most responsible position that you have ever held?

....

8. In all your practical experience, including remunerative work during vacations, which work or particular job have you liked best?

....

9. Why did you choose engineering as your profession?

....

II. CHOICE OF OTHER OCCUPATIONS

Disregarding all your training and education and all differences in compensation and social standing of the following occupations, **consider only your interest and satisfaction in working at each of the following occupations represented.** Check with a plus (+) the ten kinds of work which you would most prefer to do; and check with a minus (—) the ten which you would dislike or least like to do.

( ) Architect
( ) Automobile repairman
( ) Automobile salesman
( ) Bank cashier
( ) Carpenter
( ) Draftsman
( ) Editor of popular magazine
( ) Hotel keeper or owner
( ) U. S. Governm't astronomer
( ) Lawyer
( ) Machinist
( ) Newspaper reporter
( ) Pattern-maker
( ) Private secretary
( ) Purchasing agent
( ) Real estate agent
( ) Research worker in physics
( ) Stockbroker
( ) Toolmaker
( ) Watchmaker

III. AVOCATIONAL INTERESTS

1. What do you like to do as an avocation, hobby, or sideline?

....

2. What form of recreation or entertainment do you enjoy most in the evening after a day of study or work?

....

3. What sports do you enjoy most as a participator?

....

4. What professional and business magazines do you read regularly?

....

....

5. Have you participated in any of the following extra-academic activities:

Student debating ( ) Yes ( ) No
Dramatics ( ) Yes ( ) No
Student paper or annual book ( ) Yes ( ) No
School politics ( ) Yes ( ) No
Ever captain of a team ( ) Yes ( ) No

IV. SOCIAL INTERESTS

1. Name the social clubs, fraternities, and organizations to which you belong.

....

....

2. Have you ever held any important office in any of these organizations?
( ) Yes ( ) No
3. How many times have you made an after-dinner talk?...............
4. While you were in college did you prefer to live with a roommate or did you prefer to room alone?
( ) Roommate ( ) Room alone
5. Do you usually have a good time at smokers, conventions, and other gatherings of men?
( ) Yes ( ) No
6. Excluding engineering magazines, name three magazines which you enjoy reading.

....

V. INTERESTS OF RELATIVES

1. What is or was the occupation of your father?........................
2. What were the occupations of your:
(a) Father's father?....................................
(b) Mother's father?....................................
3. What are occupations of your brothers?

....

....

VI. TECHNICAL INTERESTS IN WESTINGHOUSE ORGANIZATION AND ITS WORK

1. Considering all aspects of each line of work as you have become acquainted with them here so far, decide which particular kind of work you would prefer to make your life occupation. Give this line of work a rank or score of (1). Give your second choice a rank of (2), and so on, giving your least desirable choice a rank of (4).

( ) Sales
( ) Works Management
( ) General Engineering
( ) Design Engineering

2. Considering the content or subject-matter of the work itself, which subject or courses in the W. E. & M. Co. Educational Department have interested you most? Write them in order of preference, the best liked first.

(1)
(2)

3. Check with a plus (+) the following lines of work which you think you would choose as your work in the Westinghouse organization. Check with a minus (—) those which you think you would not choose as your work in the Westinghouse organization.

( ) General Engineering
( ) Transformer Engineering
( ) Control Engineering
( ) Switchboard Engineering
( ) Industrial and Railway Motor Engineering
( ) Railway Equipment Engineering
( ) Material and Process Engineering
( ) Research Engineering
( ) Detail Engineering
( ) Power Engineering
( ) Industrial Sales
( ) Supply Sales
( ) Power Sales
( ) Railway Sales
( ) Marine Sales
( ) Stocker Sales
( ) Foreign Sales
( ) Production
( ) Time and Motion Study
( ) Inspection
( ) Cost Accounting
( ) Maintenance
( ) Operating
( ) Dynamo Test
( ) Transformer Test
( ) Large Industrial Motor Test
( ) Small Industrial Motor Test
( ) Detail Test
( ) Farm Lighting Equipment Test

(Do not write in the space below)

	I. Vocational	II. Other Occ's	III Avocations	IV. Social	V. Relatives	Technical
Design						
General						
Oper'g Service						
Works						
Sales						

REMARKS:

or ratings are made by a man or by men who are intimately familiar with the lines of work and opportunities open to the student engineers. With these lines of work in mind, the one doing the rating considers the man's answers to the questions of Section I., entitled Previous Vocational Interests, and decides whether the facts appearing there indicate that the man is qualified by his fundamental interests and experience to be a design engineer, a general engineer, a works management engineer, an operating engineer, a service engineer, or a sales engineer. Then turning to the *Summary* on the last page of the *Record of Interests,* the rater places a check (√) in the proper rectangular blank space under the column head, I. Vocational. Each section is considered separately in this way, a judgment is made from each class of facts, and a check is made in the proper square of each column of the *Summary.* By connecting the check marks with straight lines, a curve is obtained which shows the general tendency of the interests of the man, whether fitting him for design, general, works management, operating, service, or sales engineering. This gives a definite and permanent graphic record of pertinent facts concerning each man. Instead of a hazy vacillating general impression of the man, there is a tangible analyzed judgment of him. By keeping this on file and easily available, it is possible to have always before the executive considering the man, a careful record of previous judgments.

3. *Evaluation of Specific Questions in the Record of Interests*

To test out the value of the *Record of Interests,* it was filled out by sixty-four adults in one class and sixty in a second class of the School of Insurance Salesmanship at the Carnegie Institute of Technology. The results for each Insurance Salesmanship class are tabulated separately in order that the two sets of data will be a check on each other, and their agreement be some measure of their reliability. Later the *Record of Interests* was filled out also by thirty Westinghouse design engineers and thirty sales engineers, none of whom had been with the Company less than a year nor more than five years. The following table shows the results obtained for some of the chief questions.

Each section is discussed later and evaluated separately in the light of the results obtained.

TABLE VII.

Results Obtained from Record of Interests of Insurance Salesmen, Design Engineers, and Sales Engineers

Insurance Salesmen

No. of Question	Question	Answered (Yes) First Class	Answered (Yes) Second Class	Answered (No) First Class	Answered (No) Second Class	No. of Cases First Class	No. of Cases Second Class
I. 2.	Constructed toy?	25%	40%	75%	60%	55	62
I. 4.	Wanted toy?	27%	53%	73%	47%	15	15
I. 5.	Copied Design?	69%	47%	31%	53%	13	15
I. 6.	Had sold articles?	84%	81%	16%	19%	62	52
III. 5.	Student Debating?	51%	56%	49%	44%	51	45
	Dramatics?	45%	48%	55%	52%	53	46
	Student paper or book?	40%	52%	60%	48%	53	46

I. 1. Rank of Choice of School Studies or Subjects.

	Average Rank Given First Class	Average Rank Given Second Class	Number of Cases First Class	Number of Cases Second Class
English	3.07	3.23	56	39
Economics	3.54	2.92	46	38
History	3.60	3.29	53	45
Field Work	4.13	4.39	24	28
Shop Work	5.65	6.44	26	25
Drawing and Drafting	5.19	7.13	32	24
Testing	5.35	6.00	20	25
Laboratory	4.97	5.13	32	30
Mathematics	3.47	3.60	53	39

Design Engineers and Sales Engineers

No. of Question	Question	Answered (Yes) Design	Answered (Yes) Sales	Answered (No) Design	Answered (No) Sales	Number of Cases Design	Number of Cases Sales
I. 2.	Constructed toy?	83%	50%	17%	50%	30	46
I. 4.	For toy itself?	0%	37%	100%	63%	19	19
I. 5.	Copied design?	12%	38%	88%	62%	17	16
I. 6.	Had sold articles?	50%	82%	50%	18%	25	45
III. 5.	Student debating?	32%	47%	68%	53%	25	45
	Dramatics?	16%	27%	84%	73%	25	45
	Student paper or book?	36%	33%	64%	67%	25	45

I. 1. Rank of Choice of School Studies or Subjects.

	Average Rank Given Design	Average Rank Given Sales	Number of Cases Design	Number of Cases Sales
English	6.73	5.33	26	39
Economics	6.04	4.63	26	38
History	6.32	5.55	25	36
Field Work	5.54	5.13	26	38
Shop Work	5.65	5.98	26	40
Drawing and Drafting	5.31	5.95	26	39
Testing	3.73	3.95	26	40
Laboratory	3.15	3.88	26	40
Mathematics	1.81	3.85	27	40

I. *Previous Vocational Interests.*—Question 1, regarding college work, proved to be of significance in differentiating the men. Both the insurance salesmen and the sales engineers, particularly the insurance salesmen, liked English, Economics, History, and Field Work better than the design engineers did. The design engineers liked Mathematics, Laboratory, Testing, Drafting, and Shop better than the sales engineers or the insurance salesmen did.

Questions 2 and 3 showed some tendency for this differentiation, but they were not so valuable. Of the insurance salesmen, 25% of the first class and 40% of the second class had constructed toys; 50% of the sales engineers had constructed toys, while 83% of the design engineers had constructed toys. Question 4 showed a tendency of the salesmen to make things because they wanted them, while the design engineers made things because they enjoyed making them. Those who made things because they enjoyed making them, were 73% of the first class of insurance salesmen and 47% of the second class of insurance salesmen who made any things. 30% of the sales engineers who made things, and 100% of the design engineers who made things made them for the pleasure of construction. The other questions of this section were not so reliable, but they served to aid in forming a judgment or classification of the men.

II. *Choice of Other Occupations.*—In this list of occupations, there were fifteen occupations which were judged by fourteen people to be occupations that would be chosen or preferred by a man with engineering interests as primary. The other fifteen occupations were judged by the same people to be occupations that would be chosen by a salesman type of man. The occupations were carefully chosen from a much larger list; and the judgments or classifications of the occupations by each of the fourteen people were tabulated so that any occupation concerning which there was not common agreement was detected and eliminated from the list. It might be said that the occupations intended to be chosen by a sales type of person are comparatively higher-level occupations than those intended to be chosen by the engineer type. This condition was allowed to exist, because all the men choosing these occupations are engineers and are already inclined to choose engineering type of occupations. By having them choose from a list containing very desirable sales type of occupations, there is a stronger tendency for the group to be differentiated. The Record of Interests as filled out by the salesmen and engineers contained this list of thirty occupations which were to be checked plus (+) or minus (—) according to the directions shown with them. The number of plus and minus checks made by each group for each occupation are shown in Table VIII. The same facts are shown in graphic form in Diagrams 7, 8, 9.

TABLE VIII

Choices of Occupations by Insurance Salesmen, Sales Engineers and Design Engineers

	Insurance Salesmen									
Occupation	1st Class		2nd Class		Both Classes		Design Engineers		Sales Engineers	
	+	—	+	—	+	—	+	—	+	—
Actor	24	25	24	21	48	46	5	16	6	31
Architect	28	19	24	18	52	37	19	3	29	10
Auto repairman	19	25	8	27	27	52	16	5	15	15
Auto salesman	52	8	46	3	98	11	10	6	44	1
Bank cashier	28	21	35	8	63	29	8	13	19	20
Carpenter	14	23	4	31	18	54	11	5	9	22
Captain of a ship	22	23	22	16	44	39	14	8	21	13
Chemist	17	29	16	26	33	55	15	5	25	15
Detective	23	31	20	24	43	55	6	17	7	33
Draftsman	16	36	8	27	22	63	16	7	9	25
Editor of magazine	30	16	33	10	63	26	4	17	19	17
Hardware sales	14	36	10	34	24	70	2	16	4	22
Hotel keeper	19	25	30	15	49	40	2	21	19	18
U. S. Astronomer	9	28	12	26	21	54	8	11	9	24
Lawyer	37	10	39	4	76	14	9	9	29	13
Locksmith	1	44	0	37	1	81	3	9	3	30
Locomotive engineer	20	19	11	27	31	46	17	3	23	6
Machinist	14	26	11	26	25	52	20	3	17	20
Newspaper reporter	38	8	37	6	75	14	5	14	25	9
Pattern-maker	5	39	2	25	7	64	10	6	7	23
Policeman	1	50	0	48	1	98	0	27	0	43
Private secretary	38	9	22	17	60	26	3	20	14	13
Purchasing agent	46	8	41	3	87	11	9	8	41	2
Real estate agent	42	8	47	3	89	11	6	16	29	7
Research worker in physics	12	27	14	21	26	48	20	3	22	13
Sculptor	14	31	9	21	23	52	5	15	3	22
Statistician	13	32	18	17	31	49	7	18	12	25
Stockbroker	35	8	35	7	70	15	7	8	32	5
Toolmaker	3	31	4	30	7	61	13	8	3	25
Watchmaker	2	39	0	35	2	74	5	11	0	33

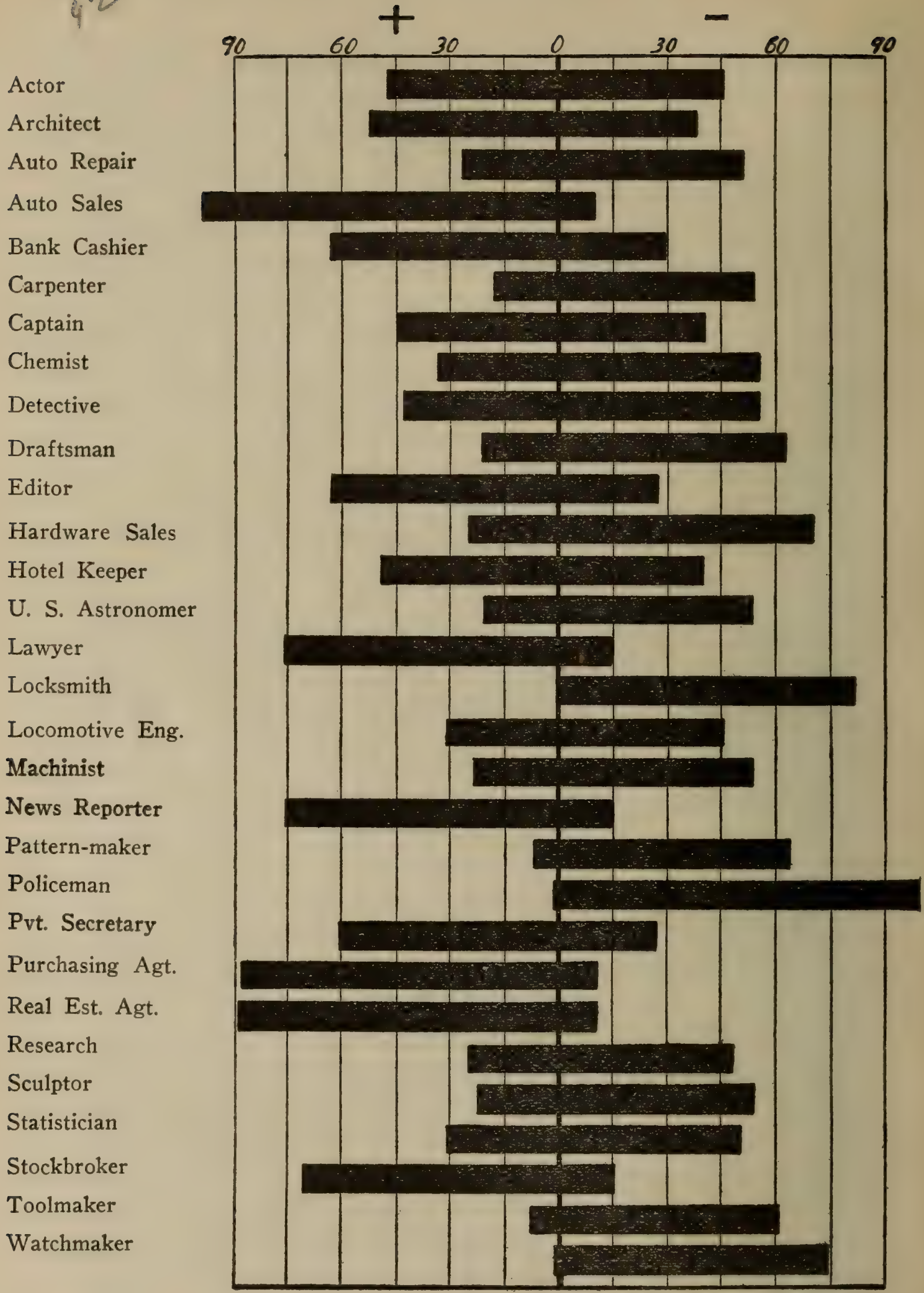

Diagram 7. Number of Choices Showing Preferences for (+), or Rejection of (—) Occupations by Insurance Salesmen. Number of men represented, 124.

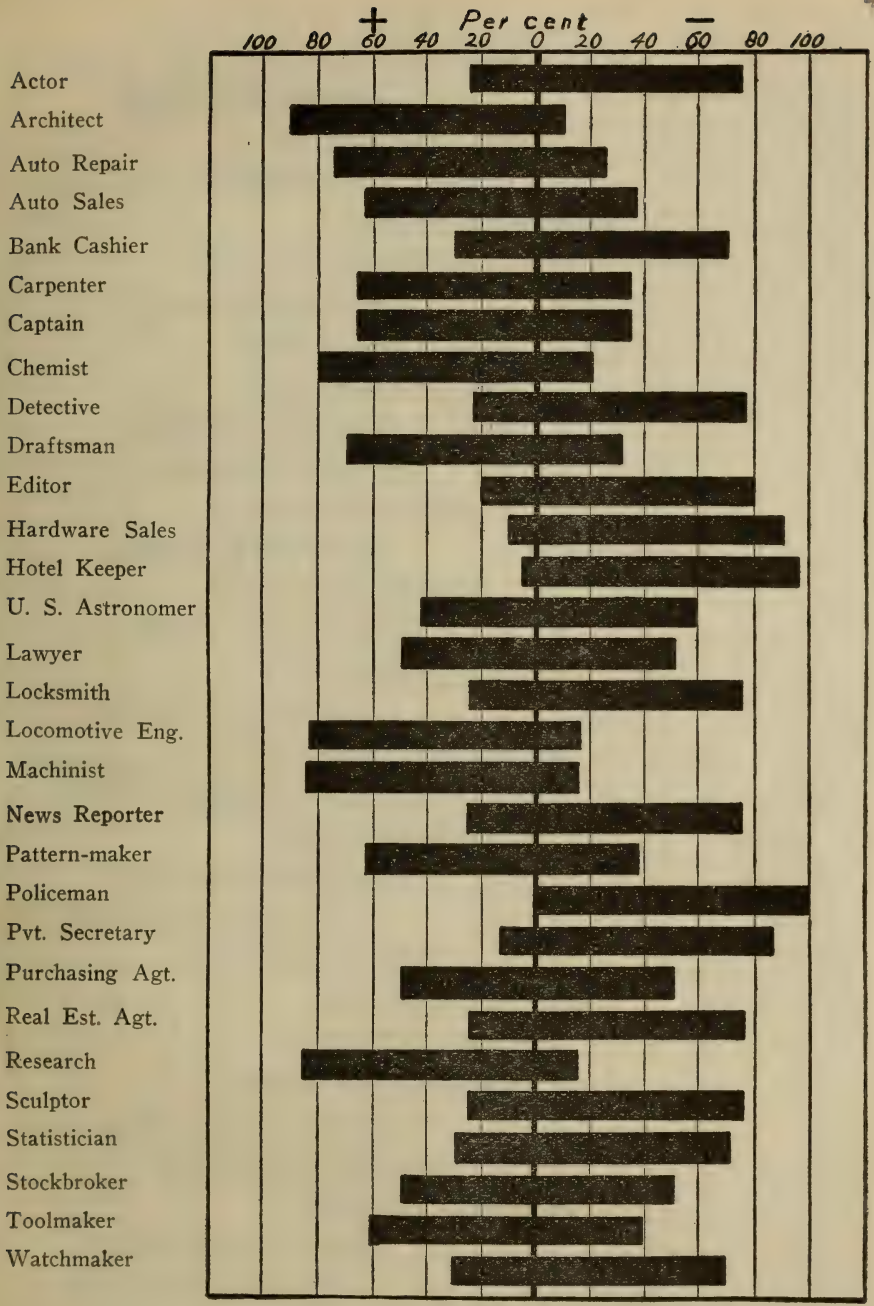

Diagram 8. Percentages of Choices Showing Preference for (+), or Rejection of (—) Occupations by Design Engineers. Number of men represented, 28.

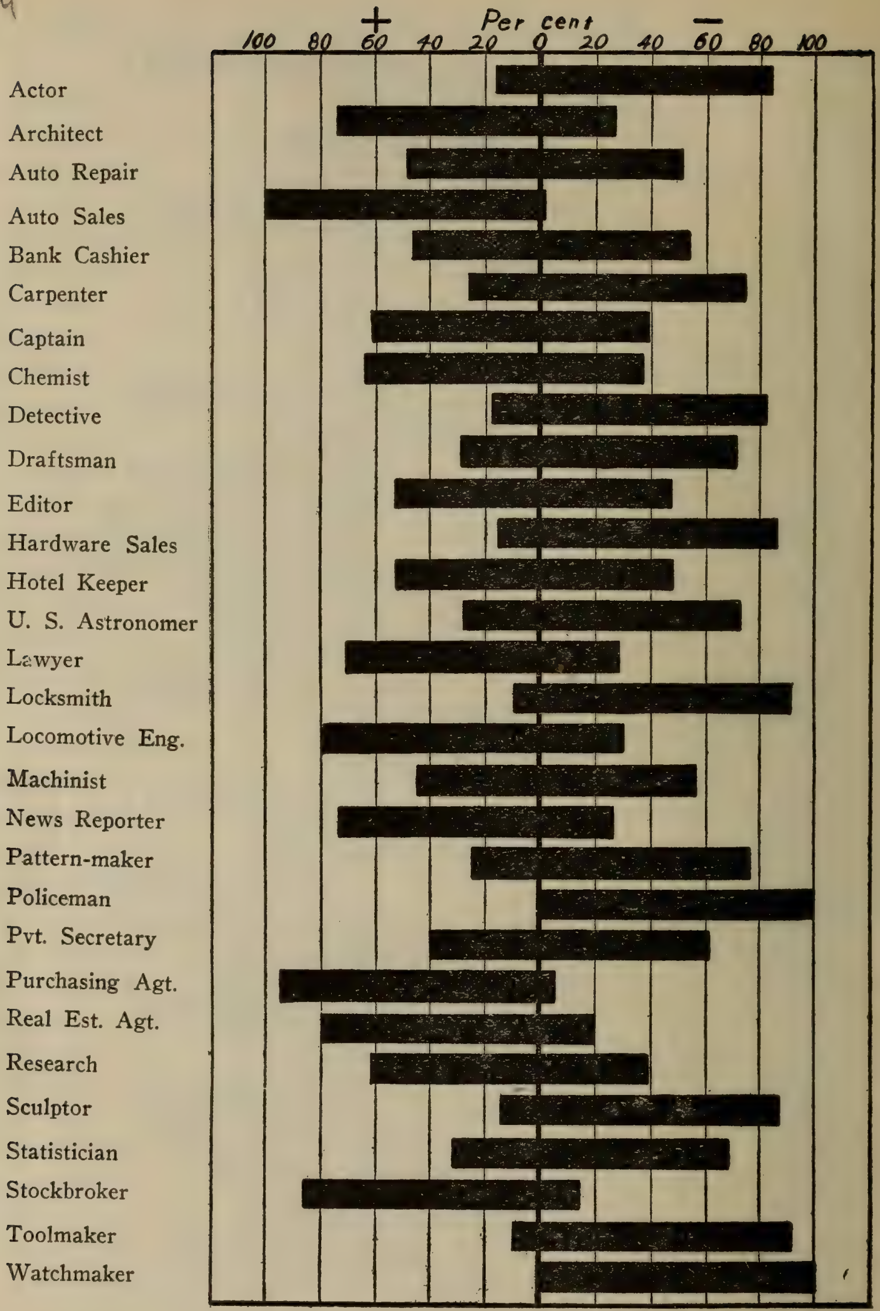

Diagram 9. Percentages of Choices Showing Preference for (+), or Rejection of (—) Occupations by Sales Engineers. Number of men represented, 50.

From the list of thirty occupations, twenty occupations were later chosen, because they had given the best results for differentiating; and a new form was prepared as reproduced on page 36. The student engineers are directed to check ten of them with a plus (+) as the more desirable, and to check ten with a minus (—) as the less desirable. The twenty occupations classified as those chosen by an engineering type of man and those chosen by a sales type of man are as follows:

Occupations Chosen by Engineering Type	Occupations Chosen by Salesman Type
Architect	Automobile salesman
Automobile repairman	Bank cashier
Carpenter	Editor of popular magazine
Draftsman	Hotel keeper or owner
U. S. Government astronomer	Lawyer
Machinist	Newspaper reporter
Pattern-maker	Private secretary
Research worker in physics	Purchasing agent
Toolmaker	Real estate agent
Watchmaker	Stockbroker

The relative percentage of the sales or engineering type of occupation chosen by a man indicates whether he is a sales type or an engineering type of man. The scoring method explained more fully is as follows: A stencil in the form of a cardboard with perforations or slots allowing only the engineering type of occupations to be visible is placed over the list of occupations which have been checked. The number of plus marks is counted and recorded in the margin. The number of minus marks is also recorded. Then this stencil is removed and another stencil is placed over the list, allowing only the sales type of occupation to be visible; and then the number of plus and minus marks is recorded. The number of *plus* marks before engineering occupations is added to the number of *minus* marks before sales occupations in order to get the number of checks in favor of engineering occupations. The number of *minus* marks before engineering occupations is added to the number of *plus* marks before sales type of occupations to get the number of checks in favor of sales occupations. Finally the number of marks in favor of sales occupations is divided by the total number of check marks to get the percentage of marks in favor of sales occupations.

It would not be necessary to count both the plus and minus marks if all the subjects checked all the occupations; but this method of scoring can be used even though not all the occupations are checked.

The *Record of Interests* papers of the salesmen and engineers were scored according to the above method; and the results with only the twenty selected occupations being considered are presented here. Diagram 10 shows the percentages of sales occupa-

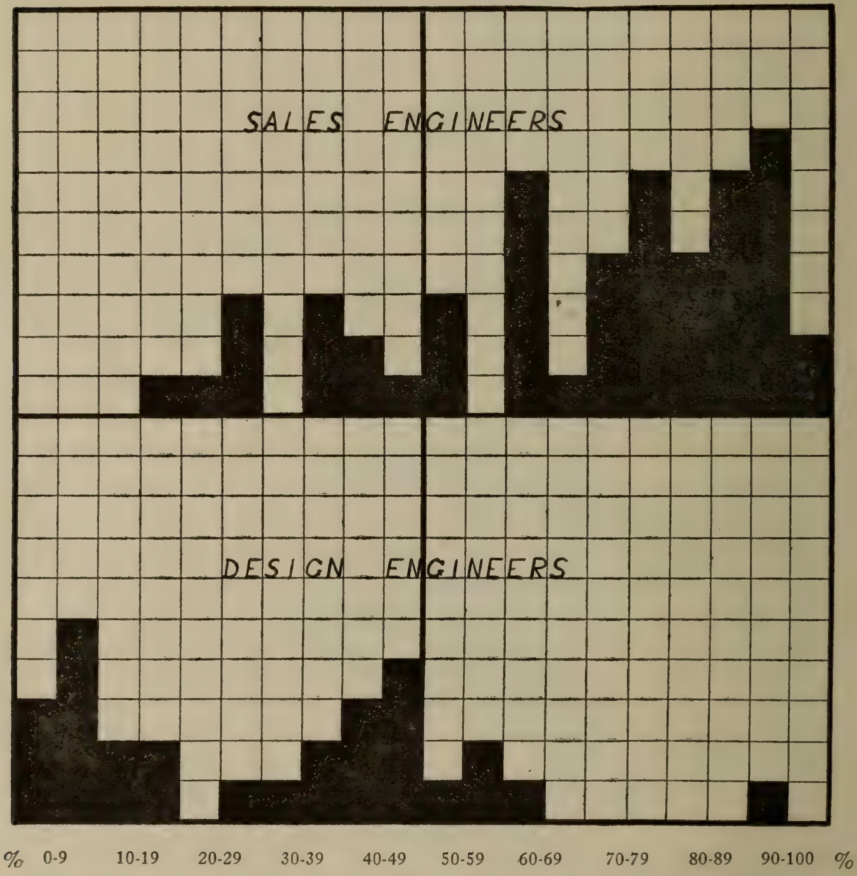

Diagram 10. Percentages of Choices Showing Preference for Occupations requiring Sales Type of Person.

Considering the diagram as a four-fold table, the interest test (Record of Interests) places correctly eighty-two per cent of the engineers. $r_U = .84$.

tions chosen by each group. The percentages of sales occupations chosen are shown along the base line or x-axis. The height of the columns represents the number of men choosing the particular percentages of sales occupations. For the insurance salesmen the percentages of sales occupations chosen were 73 per cent for the first class and 80.6 per cent for the second class. For the sales engineers the preference for sales occupations was 67.7 per cent. For the design engineers the preference for sales occupations was only 30.0 per cent.

This section, "Choice of Other Occupations," is one of the most reliable sections of the *Record of Interests;* and no subject ever failed to fill it out. The men take an interest in choosing the occupations and expressing their preference. The engineers and the salesmen showed a definite tendency to like or be interested in occupations which in nature of work were similar to those they were already following. The kind of occupations which they thought would give them the greatest satisfaction to follow was a significant criterion of the kind of work in which they could be and were already successful.

By computing for each engineer the percentage which his choices of occupations of a sales nature bore to his total number of choices, a definite measure of his sales engineering interests as opposed to design engineering interest was obtained. I assumed that if more than fifty per cent of a man's choices were occupations requiring a sales type of person for success in them, that man was a sales type of person; and if more than fifty per sent of the man's choices were occupations requiring a design engineering type of person, that man was a design engineering type of person. By this measure, 78 per cent of the sales engineers were of a sales type; and 82 per cent of the design engineers were of an engineering type. Or assuming that we did not know the actual occupations of the engineers, those engineers which this test of interests alone would select for sales engineering, would be 89 per cent correctly placed or classified; and the men which this test of interest selected for design engineering would be 68 per cent correctly placed or classified.

III. *Avocational Interests.*—Questions 1, 2, 3, and 4 did not show any special differentiation except as they showed that the sales type of man was more interested in the social sports while the engineering type often enjoyed photography or some professional or technical hobby. Question 5 showed that there was a definite tendency for the sales type of man to take more active part in extra academic activities, (See Table VII). 51 per cent of the insurance salesmen of the first class, and 56 per cent of the second class, 47 per cent of the sales engineers, and 32 per cent of the design engineers had taken part in student debating. 45 per cent of the first class and 48 per cent of the second class of insurance salesmen, 27 per cent of the sales engineers, and 16 per cent of the design engineers had taken part in dramatics. 40 per cent of the first class and 52 per cent of the second class of insurance salesmen, 33 per cent of the sales engineers and 36 per cent of the design engineers had taken part on a student paper or annual book.

IV. *Social Interests.*—The answer to the questions on social interests were not significant in their nature in differentiating the men, except as they were a definite means of showing whether or not the man has social interests and is congenial. In answer to question 5, 60 per cent of the first class and 67 per cent of the second class of insurance salesmen, 77 per cent of the sales engineers, and 77 per cent of the design engineers preferred a roommate. The other results of this section as a whole were consistent with the facts of differentiation shown in the other sections.

V. *Interests of Relatives.*—The interests of the relatives as shown by their occupations indicated a nature definitely similar to the choice made by the man considered, but there were exceptions, so that the choice of occupations made by relatives could not be used as a criterion of the proper choice for the man, except as it might be consistent with and strengthen the judgment of a man's interests as based upon the other facts of the total *Record of Interests.*

VI. *Technical Interests in the Westinghouse Organization and Its Opportunities.*—Here the man is asked for a definite statement of his particular interests in the Westinghouse Company. The results obtained in this section agree almost perfectly with the choice of kind of occupation indicated in the other sections.

IX. Application of Psychological Tests to the Problem

1. *The Nature of Mental Ability and Its Problems for Tests*

By psychological tests, we mean those tests which are consciously based upon psychological principles and are for measuring a certain mental process or processes. Often such a test is intended to measure general intelligence. By general intelligence is meant not general information, but what is synonymously called menal alertness, mental capacity, or innate mental ability. In general, psychologists accept the theory that general intelligence is composed of a group of mental abilities or factors. Practically the same conception is held by the laymen; for when a layman judges or makes an estimate of another person's general intelligence, he considers that person's particular capacities and abilities all together, and approximates a sort of average of them which is compared with the averages of other people's capacities and abilities. However, it is recognized that, except in the sense of a very broad general intelligence, people are individually different in that the general intelligence of one is composed of particular capacities and abilities different in degrees of perfection from those in the group of particular abilities composing another person's general intelligence. That is, it may be said that there are different kinds of intelligences. These different kinds of intelligences are largely due to particular interests directing the whole general intelligence in certain directions; but on the other hand, the interests are given substantial basis by particular abilities which make activity in a particular line easy and interesting. In this way, what is practically considered as a kind of intelligence directed by particular interests, is a group of special abilities developed and integrated so as to be of practical use in the life of the individual. If general intelligence or any kind of intelligence is analyzed very minutely, it is found to consist of very particular abilities, which are neural bonds between a particular situation and a particular response. Certain ones of these are essential for certain special abilities. If these essential very particular abilities are not present, the individual is not considered as specially qualified for the particular work. Other abilities or all of them together as general intelligence, may function vicariously in accomplishing to a lesser degree what is done by a special ability; but ability in that particular kind of work is limited by the weakness or lack of the ability peculiarly essential for marked success in it. It is the differences between individuals in the degree to which they possess these special abilities that differentiates them for particular lines of work. Such a special ability integrated and functioning with other abilities is a kind of intelligence, which, if tested, would yield a measure of potentiality for success in a particular kind of occupations or kind of work. Such a test may be a special ability test or it may be a trade test.

Success in some kinds of work may require not a special ability but a certain amount of general intelligence, which is considered as a certain potentiality in all of the large group of abilities usually functioning in the many activities carried on to a more or less extent by all persons. For an occupation in which greater general intelligence means so much greater capacity for success, persons could be differentiated by a general intelligence test. Such a test measures the abilities composing and therefore correlating with the average of the group of abilities called general intelligence.

These hypotheses are explained here as being the most pertinent to the problem being studied. They are stated in the form of hypotheses, not as a solution to the problem, but as a restatement of the psychological questions raised before in the Introduction. The method for attempting to answer the psychological questions, was to work in accordance with these hypotheses. First, a general intelligence test was given to ninety-four graduate student engineers. Later, a test was devised which was intended to test special ability for particular kinds of work.

2. *The Results of a General Intelligence Test*

The general intelligence test used was the Personnel Bureau Test VI., which is a modified form of the Army Alpha general intelligence test. This test was given to ninety-four graduate engineers who were students in the Educational Department of the Westinghouse Electric and Manufacturing Company. Most of these men had been in the Educational Department from six months to a year. The men were already classified according to the kind of work to which they were to be assigned. The average of the test scores for each group is shown in Table IX.

TABLE IX.

Averages of General Intelligence Test Scores for Each Group of Graduate Student Engineers.

Group	Mean Score	Median Score	Estimated Rank in Intelligence, Committee's rating
Design engineers	154	150	12.95
Operating, Service, Works	140	144	84.2
General engineers	137	135	59.9
Sales engineers	129	130	56.5

The test scores for each group of engineers are shown graphically in Diagram 11, in which the height of each column indicates the number of men making any particular score shown on the horizontal axis. Although it has not been the intention to select the men with greater mental ability for any particular line of work, the results of the test indicate that there has been a tendency to select the men with greater mental ability for engineering, particularly design engineering. This agrees with the results of the study of the technical school grades. However, the difference is not sufficient to differentiate the men, except that a critical score might be established, below which a man could not be accepted for design engineering. The correlations between this test and other tests and ratings are shown in Table X.

On examining the cases in which the test scores do not agree with estimated intelligence, we find that there seem to be certain tendencies causing the disagreement. A table of the cases in which there is the greatest disagreement, and those in which there

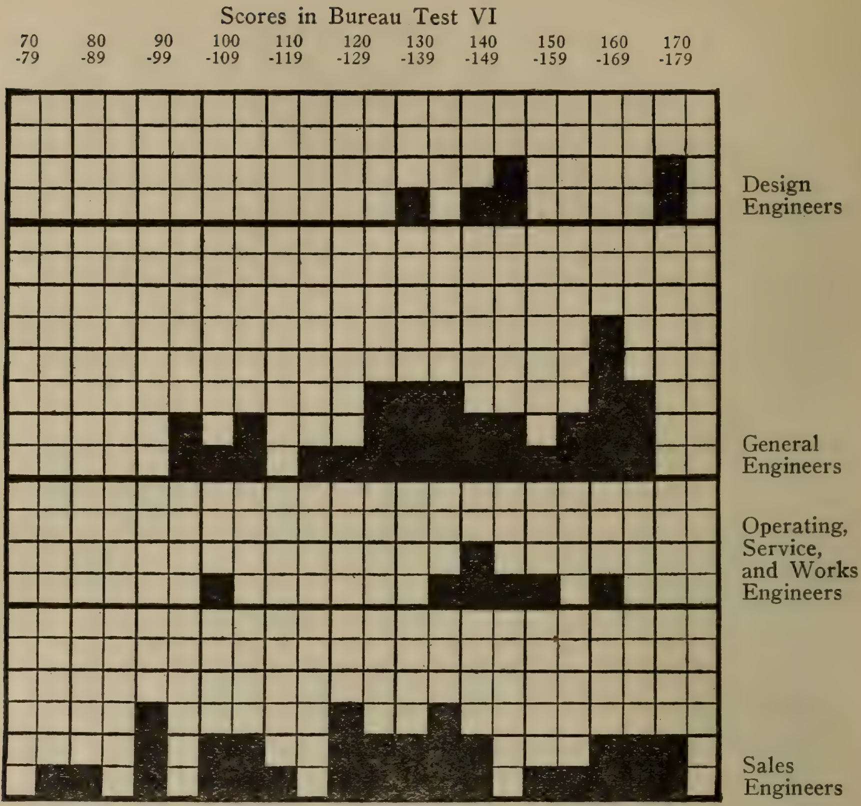

Diagram 11. Scores in Bureau Test VI of Graduate Engineers Classified by Occupations.

TABLE X.

Correlations of Bureau Test VI Scores with Other Criteria.

Criteria Correlated with Test VI.	Number of Cases	Correlation (r)
Estimated intelligence, committee's rating..........	74	+.46
Composite of technical school grades	56	+.37
Technical school grades in languages	43	.0
Technical school grades in mathematics	34	+.34
Technical school grades in shop	24	+.67
Technical school grades in engineering	53	+.26
Technical school grades in academic subjects	35	.0
Company shop ratings	58	.0
Ratings at employment interview	18	+.58
Rating in intelligence at employment interview	18	+.57
Bureau Test 10, Part I (Insurance salesmen Class 1)..	64	+.64
Bureau Test 10, Part I (Insurance salesmen Class 2)..	58	+.91
Bureau Test 10, Part I (Engineers)	18	+.69
Bureau Test 10, Part II (Engineers)	18	+.38

is the greatest agreement is presented for study and comparison of those cases. See Table XI.

TABLE XI.

Cases in Which Test Scores Do Not Correlate with Estimated Intelligence and Cases in Which the Correlation Is High.

Disagreement: High Rank by Test; Low Rank by Committee

Number of Case	Rank by Test	Estimated Intelligence Rank	Assignment
1	5½	61	Engineering
2	12	57	Sales
3	18	63	Engineering
4	21	62	Operating
5	12	49	Engineering
6	10	39	Sales
Disagreement: Low Rank by Test; High Rank by Committee			
7	56½	13	Sales
8	52	16	Sales
9	52	17	Sales
10	61	26	Engineering
Agreement: Both below Average			
11	65	66	Sales
12	63	64	Sales
13	48	48	Sales
Agreement: Both above Average			
14	1	1½	Engineering, Design
15	2	5	Engineering, Design
16	8½	6	Engineering
17	8½	9	Engineering
18	12	12	Engineering
19	24	25	Engineering

In the group of those who received a high rank by the test, but a low rank by the committee, it is seen that most of the men in this group are engineers as contrasted with salesmen. These men tend to be more of the profound intellectual type as contrasted with the bright attractive type. For this reason their pure reasoning or intellectual ability tends to be underestimated. It is also interesting to note that in the case of greatest disagreement, that of No. 1, the engineer was rated on the rating scale at time of employment, and he received in physical qualities only 12 points out of a possible 20, in personal qualities only 12 points out of a possible 20, but in intelligence he received 20 points, the highest possible rating.

Of the graduate engineers who received a low rank by the test but a high rank by the committee, three are assigned as salesmen, and but one as an engineer. It is seen that there is a tendency for the man with high intelligence but comparative lack of highly-rated appearance and personal qualities to be underestimated; but the man with good or pleasing appearance and personal qualities is over-estimated in intelligence. This is the usual tendency often found, because we tend to consider other qualities which are evident, but which, although valuable traits, are not intelligence as measured by the test. Of those cases in which there was perfect or most nearly perfect agreement, all those ranking above average were engineers, and all those ranking below average were assigned to sales work. It seemed very probable that in selecting men for engineering, particularly design engineering, intelligence had been the chief qualification considered; but in choosing men for sales engineering, other qualifications had been given much weight.

3. *Construction and Evaluation of a Special Test for Differentiating Graduate Student Engineers*

(a) *Hypothesis of the Test.*—As was stated in Section II, the problem of this research was to discover or devise a method and means for selecting from the whole group of graduate student engineers those who would give their services most efficiently as sales engineers. The general intelligence test did not adequately separate the sales engineers from the other engineers. Evidently the difference between sales engineers and other engineers is a qualitative one more than it is a quantitative one in intelligence. Moreover, the difference is a relative one; for the purpose is not so much to pick a certain standard of sales engineers as it is to pick a certain number, about half of the group, who will be the **best selection from that group** for developing into sales engineers. For measuring this qualitative difference a general intelligence test could not be used. Moreover, any general intelligence test available was too easy for this group of men, because they all made high scores and were not sufficiently differentiated by it. Finally, the content or subject-matter of existing intelligence tests was not relevant to the engineering profession, and therefore did not interest or appeal to engineers as a test might be made to do. For these reasons, another test was devised to distinguish two different kinds of intelligence.

The theory upon which the test was constructed is that, of this group, the sales engineers on the one hand, and the design engineers on the other hand, are relatively at opposite extremes in the kind of intelligence possessed. The sales engineer as a result of his innate particular abilities, his environment, and his training, has interests and abilities that make for an intelligence better fitted for the work of a sales engineer. He has developed habits of thinking and attitudes toward other people which are more like those of a salesman; and his interests and apperceptions have led him to pick up and retain more of the information, particularly of a business, social, and human interest nature, which enables him to fit into the work of a sales engineer better than the design engineer type would.

The design engineer type has innate abilities and interests which with environmental influences, experiences, and training, have developed into an intelligence better fitted for the work of a design engineer. He worked intensively at his technical problems in college, and has developed habits of thinking and attitudes which are more compatible with the work of a design engineer. It was with these subtle differences between the sales engineers and design engineers in mind, that the test was devised.

(b) *Directions for the Test.*—The nature of the test, being composed partly of questions of a technical nature as well as of general information, makes it inadvisable to publish it. However, we publish here the directions just as they are given with the test. The directions include samples which indicate the nature of the various kinds of problems in the test. These samples are to explain the test so that the subject will understand clearly what he is to do with each kind of problem; therefore, they are simple and easier than the problems and questions in the actual test. Nevertheless, they sufficiently indicate the nature of this test for the purposes of this report.

TEST 10

TEST FOR GRADUATE STUDENT ENGINEERS

Prepared by B. V. Moore, Research Fellow, Expressly for the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pennsylvania.

PART I

To the Westinghouse Student Engineer:

This is a test to help you place yourself in the Westinghouse Company where you can be most successful. The results of the test will be held strictly confidential. You are asked to do your best with the test so that the Company will be in a position to give you the greatest possible opportunity. After the test has been scored, you may receive your score individually; and you may discuss the results confidentially with the executives of the Educational Department.

Fill in the blanks as indicated.

Name ....
Place of Birth ....
If not born in U. S., how many years have you been in U. S.?............
Kind of Engineering for which you are trained..........................
(Eletrical, Mechanical, etc.)
Date ....

Now read the Directions on the next two pages very carefully, but do not turn to page 4 until told to do so.

DIRECTIONS

Inside this booklet you will find a lot of things to do. Samples of all the different kinds of things to be done are given below with directions for doing each one. **Follow the directions carefully, and pay close attention to the examples so that you learn to do each thing correctly.**

(a) People hear with the **eyes** **ears** **nose** **mouth**

In such sentences, one of the last four words will make the sentence a true statement of fact. Underline the right word, thus:
People hear with the **eyes** **ears** **nose** **mouth**

Another example of the same thing correctly marked, is:
France is in **Europe** **Asia** **Africa** **Australia**

(b) locomotive—train :: horse— **hub** **buggy** **car** **baggage**

The first word, "locomotive" is related to the second word, "train," in the same way as the third word, "horse," is related to one of the words following it. You are to underline that word which is related to the third word in the same way as the first two words are related to each other. In this example, "locomotive" is related to "train" as "horse" is related to "buggy"; for a locomotive pulls a train, and a horse pulls a buggy. Therefore, **"buggy"** should be underlined, thus:
locomotive—train :: horse— **hub** **buggy** **car** **baggage**

Another example of the same thing correctly marked, is:
woman—beautiful :: man— **girl** **old** **mother** **handsome**

Handsome is underlined because a man is described as handsome in the same way as a woman is described as beautiful.

(c) The concert was **(delicious lovely delightful)**

In such sentences, only one of the words or phrases in parenthesis can be used correctly. You are to underline the correct word, thus:

The concert was **(delicious lovely delightful)**

Another example of the same thing correctly marked, is:

He **(isn't doesn't don't)** do that kind of work.

(d) little same as **large child big small**

In this kind of problem, there is always just **one** word in the group of four words which has the **same** meaning as the single word given first. In this example, "little" has the same meaning as **"small."** Therefore, **"small"** should be underlined, thus:

little same as **large child big small**

Another example of the same thing correctly marked, is:

talk same as **story truth speak hear**

(e) soft opposite of **brittle hard yielding rough**

In this kind of problem, there is always just one word in the group of four words which has exactly the **opposite** meaning of the word given first. In this example, "soft" has the opposite meaning of **"hard."** Therefore, **"hard"** should be underlined, thus:

soft opposite of **brittle hard yielding rough**

Another example of the same thing correctly marked, is:

encourage opposite of **courage inconvenience discourage inspire**

(f) Don't put all your eggs in one basket.
....The mouse that has only one hole is soon caught.
....Catch the bear before you sell his skin.
....The proof of the pudding is in the eating.

In such groups of statements, there is always just one which gives essentially the same meaning as the first one. Put a cross before the statement which means the same as the first statement, thus:

Don't put all your eggs in one basket.
.X.The mouse that has only one hole is soon caught.
....Catch the bear before you sell his skin.
....The proof of the pudding is in the eating.

Another example of the same thing correctly marked, is:

Long absent, soon forgotten.
....Absence makes the heart grow fonder.
....Distance lends enchantment to the view.
.X.Far from eyes, far from heart.

When the signal is given, you are to turn to page 4 and do these things as you have learned to do them here. Do not ask questions. If you forget how to do any of them, you may turn back to these pages, but to do so unnecessarily will waste your time.

Work rapidly. You will be allowed twenty minutes. You may not be able to get through in that time; but do as much as possible.

Mark every question. If you are not sure about your answer to something, guess at it, and go on to the next question. There are no catch questions.

When the signal is given, begin at the top of the next page, and work through the remainder of the booklet, without skipping about.

Do not turn over to the next page until you are told to do so.

PART II

On the following pages are some more things for you to do. Samples of the three different kinds of things to be done are given below with directions for doing each one. **Follow the directions carefully, and pay close attention to the examples so that you learn how to do each thing correctly.**

(a) **silver copper glass aluminum gold**

In such groups of five words, there are four words which represent things or ideas that can be thought of as similar in a certain way. That is, they can be classed under the same fundamental idea or conception. One of the five words represents something that is not like the other four words in the way that they are all like each other; and therefore, it cannot be classed with them under the same conception or category. You are to discover the fundamental idea of the classification, and underline the word that is not included. In the example above, all the materials are conductors of electricity, except "**glass**," which is relatively a non-conductor. Therefore "**glass**" should be underlined, thus:

silver copper glass aluminum gold

Another example of the same thing correctly marked, is:

shunt motor transformer telegraph sounder

synchronous alternater exciter electroplating apparatus

Transformer is underlined because it has to do with alternating current, but the other four words have to do with direct current.

(b) Other factors remaining constant, the electric current in a wire varies inversely as the resistance of the wire.

True False

You are to decide whether such statements are true or false, and then underline the appropriate word, **True** or **False**, which indicates the nature of the statement. The above statement is true; therefore, "**True**" should be underlined, thus:

Other factors remaining constant, the electric current in a wire varies inversely as the resistance of the wire.

True False

Another example of the same thing correctly marked, is:

Laminated armature cores are used, because they retain magnetism better.

True False

(c) What direct current at 110 volts will give the same horsepower as a direct current of 5 amperes at 220 volts?

Answer..........amperes

Such problems are to be solved. You may use the margin of the pages for figuring. Write the answer in the place indicated, thus:

What direct current at 110 volts will give the same horsepower as a direct current of 5 amperes at 220 volts?

Answer....10....amperes

Another example correctly solved, is:

A direct current motor uses a current of 7.46 amperes at 250 volts. A Pony brake test shows that the motor is giving 2 horsepower. What is the efficiency of the motor?

Answer....80%....

When the signal is given, you are to turn to the next page and do these things as you have learned to do them here. Do not ask questions. If you forget how to do any of them, you may turn back to these pages, but to do so unnecessarily will waste your time.

Work rapidly. You will be allowed thirty minutes. You may not be able to get through in that time, but do as much as possible.

Mark every question. If you are not sure about your answer to something, guess at it, and go on to the next thing. There are no catch questions.

When the signal is given, begin at the top of the next page, and work through the remainder of the booklet, without skipping about.

Do not turn over the page until you are told to do so.

(c) *Construction of the Test.*—A test is developed and improved much as a new machine is developed. It is brought nearer perfection, and the final efficiency attained by eliminating one difficulty after another and by taking advantage of one possibility for improvement after another, just as the dynamo was brought nearer perfection from a cast iron bipolar series-wound machine to the present efficient machine with laminated cores, commutating poles, commutating pole-face windings, compound wound field, balance coils, etc. This test was developed in much the same way. It may be found later that some of the reasons for making the test as it is, have no basis of fact; but the intention was not to fail to take advantage of any possible means or device for differentiating between the sales engineer and the design engineer type. Therefore, some of the features of the test may seem trivial and even arbitrary; but they were not discarded, because there was no proof of their futility.

To discuss the test more in detail, we shall begin with the information questions of Part I. (See Directions, a). Of the one hundred sixty questions in Part I, forty, or one-fourth, are questions of information. It is believed that the sales type of engineer has been interested in other things in addition to his books and strictly technical training. He not only has been a good mixer in college and has taken part in extra-academic activities, but he also has been interested in the affairs of the social, economic, business, and work-a-day world. The potential salesman's abilities, and with them his interests, have tended to select and retain for him those items of information which are peculiar to a sales type of person and make him such a person. A definite method was followed in order to have the questions such that a sales type of person would answer best. After studying the occupational descriptions of the various lines entered by sales engineers, a definite prospective customer in a particular industry was imagined. Supposing that I was sales manager, I outlined the kind of experiences and information I should want my salesman going to that customer to have. After doing this for each class of customer for each sales department, I prepared a composite list of kinds of information and experience which I should expect a successful sales type of engineer to have accumulated in his early life, his high school and college life, his social and fraternal life, his business life, his sports, amusements, and avocations, and his reading. With this list before me, I selected from other tests and formulated new questions which would cover these twenty or more different classes of information and interests.

The second type of problem chosen was the analogies test. (See Directions, b). Forty items of this type were included. In studying the general intelligence test papers, Bureau Test VI, the scores of the sales engineers in the different kinds of tests making up the total test were compared with the scores in those tests of the other engineers making the same total score. It was found that with the small number considered, twenty-five sales engineers and sixteen others, the sales engineers did better in the analogies test, although their total score on the whole examination was the same as the other engineers' with whom they were compared.

The next three tests might be considered or classified as vocabulary tests, but they are intended to be also more than that. Recognizing the fact that the salesman must be able to express his ideas and understand what others are trying to say, an attempt is made to measure not merely his knowledge of words, but also his sense of their finer meanings and implications in certain usages. The correct answer to a particular test item of this sort often cannot be made according to any dictionary definition or any rule of rhetoric. It depends upon usage and a fine sense of propriety. To answer them correctly the man cannot stop to reason out the answer, or he will be lost; but he must respond as he feels about the proper sense of the word. It is an attempt to measure the ability not of using words but of comprehending the meaning of other people's statements and of getting other people to undertsand us as we expect them to understand us.

The proverbs are intended to measure somewhat the same thing as the preceding types of tests measure, namely ability to read and understand sentences. In addition, it is considered as a test of the ability to generalize or think consistently. It measures the ability to interpret the gist of a complete statement rather than the meaning of words or phrases. In the proverbs test, several possible forms were considered. I thought at first that Professor L. L. Thurstone's form, a prototype with four other sentences, would be used; but this was abandoned as too long for one item. Then I thought that it would be possible to score Professor Thurstone's form as two items, one point for each sentence or phrase checked correctly. But considering the probabilities involved, this plan was dropped. By that plan, a subject in selecting the first of the two sentences to be checked, has a two-out-of-four or fifty-fifty chance. If he is a capable subject he gets the first one right. Then in checking the second one he has a chance of only one out of three; and thus the problem is made more difficult. However, if he were a much less capable subject, the first one he checks might very possibly be a wrong one; but he has two chances out of three of selecting the right one in checking a right sentence as the second one. Thus the problem is made more difficult for the more capable and less difficult for the less capable; and there is a tendency to eliminate a showing of differentiation in capacity. For these reasons, the proverbs were constructed so that there would be just one probability, namely one out of three chances.

Part II. is apparently a test of technical engineering ability. However, it is not to be considered a trade test. It would be such if it were given to a group of men, some of whom were engineers and some of whom were not, but the test is for engineers only, and is not to distinguish engineers from people that are not engineers. The technical information required to pass the test is comparatively easy for electrical engineers; for the test was designed to require only such information and engineering ability as every graduate of all standard schools would have. When the test is given to a group of engineers, it is essentially an intelligence test; but it tests a certain kind of intelligence. The hypothesis upon which it is based is that the man who is more capable as an engineer, who has his interests in the profession, and who has held himself more intensively to his books, shop, drafting board, and mathematics, is the design engineer type, and is the kind of engineer who will tend to pass this kind of test better than he would pass Part I. It is expected that a pure design engineer type of man will pass such an intelligence test better if the vocabulary and content is that with which he is accustomed to work and think about.

The first kind of problem or question in Part II, (a), is, as the Directions explain, a test of ability to deal with fundamental conceptions found in mechanics, physics, or engineering. The test is intended to measure the subject's alertness in dealing with or in juggling such technical ideas. It is even hoped to be a test of association or originality in seeing the relations involved in such fundamental conceptions. It calls for analysis and generalization in the technical field.

The second type of question, Part II, Directions (b), is composed largely of questions calling for technical information; but the questions are so stated that the subject must read them carefully and think straight to give the right answer; for they cannot be answered directly from general principles or textbook information, but require the application of general principles.

The third type of problem, Part II, Directions, (c), is manifestly a straight mathematical engineering problem. The problems are not highly technical, but require straight thinking and accurate computation. Problems in mensuration, mechanics, and general physics are included as well as problems in electrical engineering.

In a psychological test with a time limit, it seems most logical to have the steps or items to be solved, of equal difficulty, particularly if speed is considered as a measurable factor of the ability to be tested. Therefore, if the items cannot be made of equal difficulty, it does not seem consistent to arrange the items in the order of their difficulty, putting the most difficult to be solved last. This tends to minimize the differentiating process rather than make the most of it. The capable subject gets through the easier items first, but is held back by the more difficult material ahead, while the less capable subject coming through the easier material then tends to catch up with the capable man. Moreover, the difficult material which the capable person might be able to solve, but which the less capable man never could solve, is never reached by either. It might be argued that the more difficult material be placed first and the easier later, so that the less capable subjects would have to pass it over after spending a little time on it. The capable man would get credit for it and also for much more easier material, which would make his score much larger than that received by the less capable man. Thus the differentiation would be greater. For these reasons, no especial effort was made to rank the problems, particularly in Part II, in order of difficulty; but some attempt was made to keep the difficulty fairly constant. Of course the first few items were made easier so that all subjects could get the correct idea and get fairly started.

(d) *Standardization of the Test.*—In the process of developing and testing the test, Part I. was given first to the members of the seminar of the Bureau of Personnel Research, composed of two persons with the degree of Doctor of Philosophy in psychology, and six graduate students. The number of the item which was reached by each subject at the end of twenty minutes, was checked, and the subjects asked to complete all the items of the test. Also, the subjects in the seminar were asked to criticize and put a question mark after each item that was ambiguous or of questionable reliability. Then both the errors and the criticisms were tabulated for each of the one hundred sixty items. After making a few minor changes in Part I. as a result of this first trial, it was given to a class in the School of Insurance Salesmanship. Sixty-one men and three women, about half of whom were college people, were in this group taking the test. Part I. was then revised a second time and given to fifty-five men and five women in another class in the School of Insurance Salesmanship.

The process of constructing and standardizing Part II. was somewhat different. The True-False questions were taken from Professor E. L. Thorndike's engineering test. The problems were taken partly from Professor L. L. Thurstone's engineering tests, partly from standard engineering textbooks, and part were originally devised by myself. The disparate word test items, that is, the groups of words with one word not included in the fundamental conception, were all originally devised by myself.

For standardizing Part II., it was studied and the problems worked by two engineers of the Westinghouse Electric and Manufacturing Company. Then the problems were worked, and the whole of Part II. carefully criticized by Professor W. R. Work of the Department of Electrical Engineering, Carnegie Institute of Technology. Then both Part I. and Part II. were given to three seniors in electrical engineering just graduating from the Carnegie Institute of Technology. After a third revision, the entire test, Part I. and Part II., was given to twenty-eight design engineers and two general engineers in the Westinghouse Electric and Manufacturing Company. Later the entire test was given to fifty-nine sales engineers in the same company.

The specifications for selecting the Westinghouse engineers for the test were: (1) They all should be graduates of technical schools. (2) They should have been out of school and in actual work with the Company not more than five years and not less than one year. (3) The design engineers should be beyond doubt of the type desired in design engineering. They should have proven successful and should be satisfied in their work. There should be no doubt that they were properly placed. (4) The sales engineers should be beyond doubt of the type desired in the sales department. They should have proven successful and should be satisfied in their work. There should be no doubt that they were properly placed as sales engineers.

With these specifications, the heads of the engineering departments selected the design engineers; and the whole list was gone over carefully by the Chief Engineer. The sales engineers were selected in a similar way by the sales managers. A few of the sales engineers had been out of school more than five years; but it is believed that the two groups were composed of as pure type representatives of the two kinds of engineers as could be obtained. In addition to helping make the selection, the Chief Engineer rated the design engineers on their ability as design engineers; and the sales managers rated the sales engineers on their ability as sales engineers.

(e) *Results of the "Test for Graduate Student Engineers."*—The results of the test given to the different groups can be summarized briefly. Because the test was revised after giving it to the first class in the School of Insurance Salesmanship, the scores can not be compared with the scores of the other groups. The insurance salesmanship classes had also taken Bureau Test VI., and the correlations between the scores of that test and those of Part I, were, $r = +.64$ for the first class, which took the original form of the test; and $r = +.92$ for the second class, which took the revised form of the test. Of the engineers who took Bureau Test VI, 18 also took the Bureau Test 10. For these 18, the correlation between Test VI and Part I of Test 10 was $r = +.69$; and between Test VI and Part II, the correlation was $r = +.38$. The correlation between the committee's original estimate of intelligence and Part I was $r = +.49$; and between estimated intelligence and Part II, the correlation was $r = +.76$. Evidently the estimate of intelligence was influenced by the student engineer's manifestation of engineering capacity.

Considering only the design engineers, Diagrams 12, 13, and 14 are four-fold tables showing the relation between the results of Part I and the Chief Engineer's ratings, between Part II and these ratings, and between a composite of Part I and Part II and these ratings. The composite score was made by adding the score in Part I to the score in Part II in terms of standard devia-

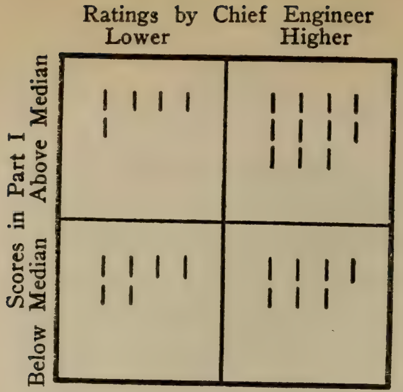

Diagram 12. Comparison of Scores in Part I with Chief Engineer's Rating of Design Engineers. $r_U = .22$.

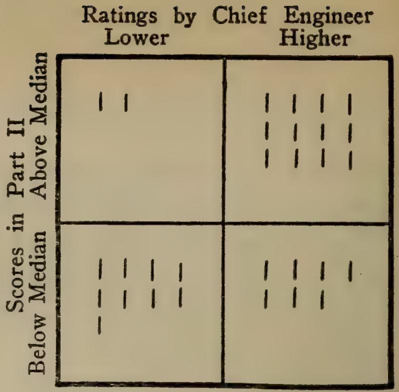

Diagram 13. Comparison of Scores in Part II with Chief Engineer's Rating of Design Engineers. $r_U = .59$.

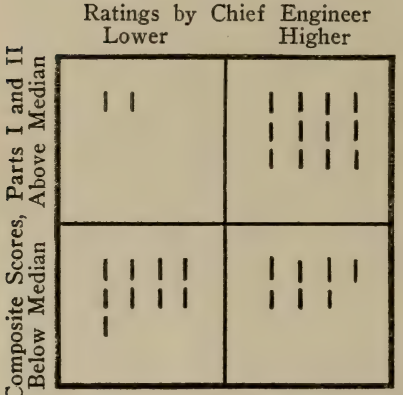

Diagram 14. Comparison of Scores in Composite of Part I and Part II with Chief Engineer's Ratings of Design Engineers. $r_U = .66$.

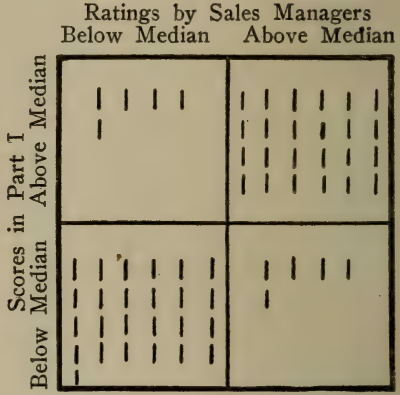

Diagram 15. Comparison of Scores in Part I with Sales Managers' Ratings of Sales Engineers. $r_U = +.86$

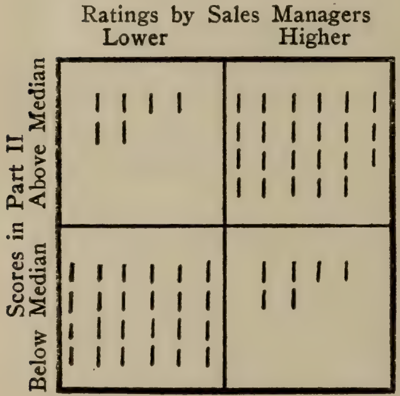

Diagram 16. Comparison of Scores in Part II with Sales Managers' Ratings of Sales Engineers. $r_U = +.81$.

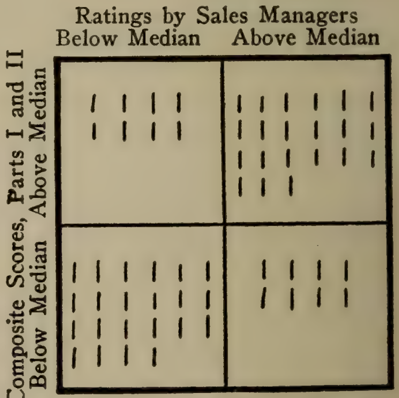

Diagram 17. Comparison of Scores in Composite of Part I and Part II with Sales Managers' Ratings of Sales Engineers. $r_U = +.66$.

tions. It is evident that Part II, the technical part prepared for design engineers, correlates more nearly perfectly with the ratings than Part I does. The composite score, which takes into account both the special engineering capacity and the general intelligence or mental alertness of the man, correlates a little more nearly perfectly. Diagrams 15, 16, and 17 show the same relations for the sales engineers; that is, the correlations between the test and the ratings made by the sales managers.

Considering again only the design engineers, the mean of the scores in Part I was 109.3; and the mean of the scores in Part II was 37.0, which is approximately *one-third* of the mean for Part I, 37.0 multiplied by three being 111.0. For the sales engineers, the mean of the scores in Part I was 87.6; and the mean of the scores in Part II was 22.7, which is approximately *one-fourth* of the mean for Part I, 22.7 multiplied by four being 90.8. Thus the sales engineers do relatively better in Part I as compared to Part II than the design engineers do. Comparing in another way, the design engineers do relatively better in Part II as compared to Part I than the sales engineers do; for the mean of their scores in Part II is more than one-third of the mean of the scores in Part I.

Diagram 18 is a scatter diagram showing the relation between Part I. and Part II. for the scores of the design engineers and the sales engineers. Diagram 19 shows the same relation between the percentiles of each man in Part I and Part II. The circles (O) represent the sales engineers; and the crosses (X) represent the design engineers. One purpose of the test is to distinguish sales engineers from design engineers. According to the hypothesis for the test, the men who did well in both parts of the test and appear in the upper right-hand quadrant of the diagram, are mentally capable of being either sales engineers or design engineers because of their superior general all-around intelligence, or because of their superior intelligence in at least these two fields. The men who did poorly in Part II. but very good in Part I, should be those whose kind of intelligence fits them better for the work of a sales engineer. The larger percentage of circles in this quadrant substantiates this part of the hypothesis. Those

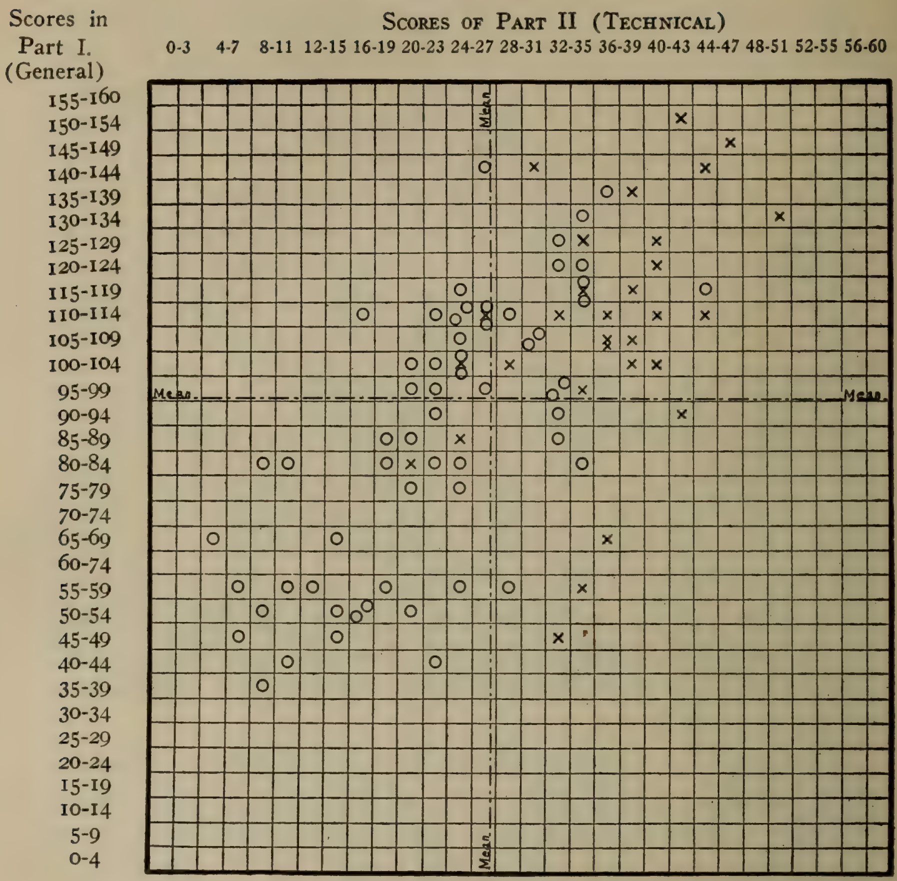

Diagram 18. Scatter Diagram Showing Relation of Scores in Part I to Scores in Part II for Design Engineers (+) and for Sales Engineers (o).

who did poorly in Part I. but very good in Part II., should be those whose kind of intelligence fits them better for the work of a design engineer. The larger percentage of crosses appearing in this quadrant substantiates this part of the hypothesis. Those doing poorly in both Part I. and Part II., might be equally successful in either line of work, as far as mental ability is concerned; but they are not as successful as any of the others might be if properly placed in the right line of work. As a whole the hypothesis is substantiated by the results. There are some

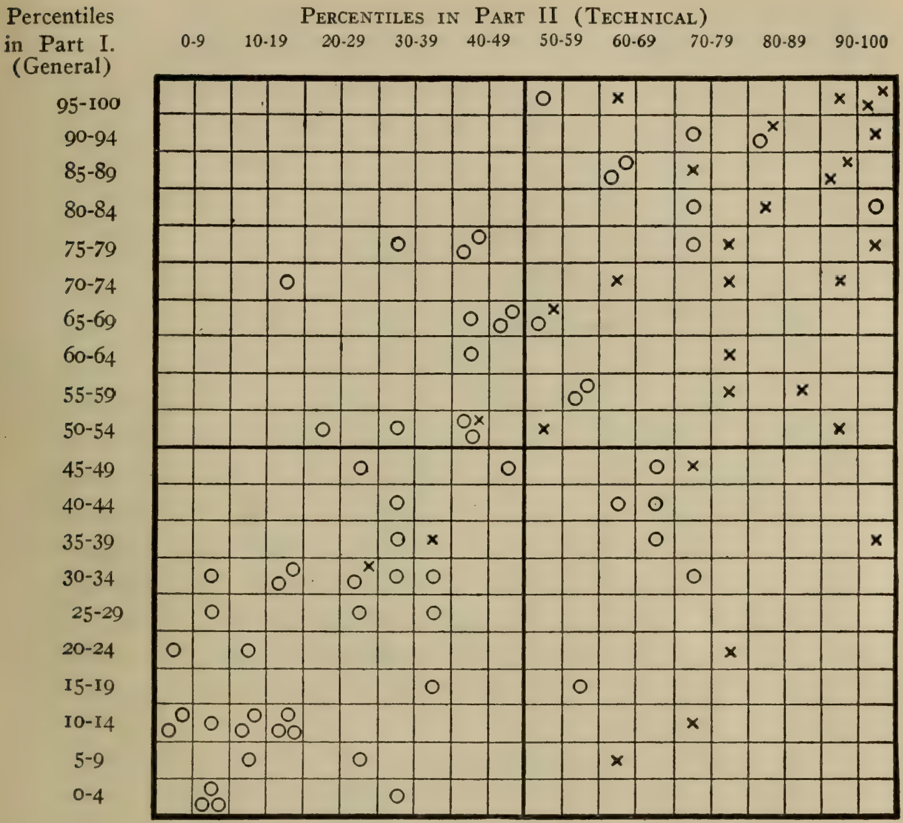

Diagram 19. Scatter Diagram Showing Relation of Scores in Part I to Scores in Part II in Terms of Percentiles for Design Engineers (+) and for Sales Engineers (o).

exceptions as seen from the positions of the circles and crosses on the scatter diagram; but investigation shows reasonable causes for these, which do not disprove the hypothesis. The test was made for graduate student engineers in the Educational Department of the Westinghouse Company, and all these engineers are always just graduated from the technical schools. Therefore, they would not have the difficulty of having specialized in industry for several years and having forgotten some of their theoretical or technical training. Some of the design engineers who took this test had been doing very highly specialized work for five years, and had forgotten some of the information in other lines of electrical engineering. For this reason, they may not have done so well in Part II, although they were regarded by the Chief Engineer as among his best engineers, particularly because of their experience, conscientious work, and constant application. However, I do not think that the specialization or experience of the design engineers nor of the sales engineers materially affected their scores; for Part II is a test of engineering aptitude and not of engineering information, and Part I is a general intelligence or mental alertness test. The correlation between Part I and Part II was r = +.42 for the design engineers, and r = +.84 for the sales engineers. If the design engineers have special capacity for engineering, as we believe they have, it is to be expected that their score in Part II, which tests engineering capacity, would correlate less with their scores in Part I, which is a general intelligence test, than the sales engineers' scores in Part II would correlate with their scores in Part I. The scatter diagram of the scores of the design engineers in Part II shows that the correlation between the parts is lower because some of the design engineers had special aptitude in engineering, but could not do well in the general intelligence or mental alertness test.

(f) *Statistical Interpretation of the Results for Occupational Placement.*—The test is to be used in two different ways for two different purposes. The first use is to separate the men who are best fitted to be sales engineers from those who are best fitted to be design engineers. What is desired in this case is to know for what the men are best fitted by their special abilities, not considering their general intelligence or mental alertness. A man might be more successful as a design engineer and might make a better score in Part II than another man; but even so he would not be so well placed if he is placed as a design engineer when he could be still more successful as a sales engineer. Each man should be placed not where he would be merely successful, but where he could function most efficiently and be most successful. Therefore a single score in a sales test or in an engineering test could not be relied upon to place the men; for the good all-around man would do best in both kinds of work, and best in both kinds of tests. However, some measure of the kinds of abilities or the qualitative differences in intelligence could be obtained by subtracting the score of each man in one test from his score in the other test. Suppose, for each individual, we subtracted the score of Part II in terms of the standard deviation from the score of Part I in terms of the standard deviation. The man who had a score in Part I which was considerably higher than his score in Part II would have a large algebraically positive difference between his scores, and he would be a sales engineer type of man. This great difference between his scores in each part of the test might be because he did well in Part I, or did poorly in Part II, or for both reasons. In any case, he would be better fitted for sales engineering than he would be adapted for design engineering. The man who had a score in Part I considerably lower than his score in Part II, would have a large algebraically negative difference between his scores; and he would be a design engineer type of man. This great difference between his scores in each part of the test might be because he did poorly in Part I, or did well in Part II, or for both causes. By use of this method, that is, transmuting the scores into terms of sigmas and subtracting the score in Part II from the score in Part I, those who get the greater algebraically positive differences are to be considered the more specially fitted for sales engineering; and those who get the greater negative differences are to be considered the more specially fitted for design engineering. The practical use of this method is to rank the men according to the algebraical differences between their respective scores in Part I and Part II, and then count down the list until the desired number of sales engineers is obtained. That is, the man who did well in Part I, but poorly in part II, would rank high in the list according to the algebraic difference between his score in Part I and his score in Part II, and he would be chosen for sales engineering. This method, theoretically, selects the men who can function most efficiently as sales engineers, and leaves those who can function most efficiently as design engineers.

To check this method of classifying and ranking the thirty design engineers and the fifty-nine sales engineers, the score of each individual for Part II was subtracted from his score in Part I, both scores being in terms of their respective standard deviations. This gave positive although not the most desirable results in separating the sales engineers from the design engineers. These results are shown graphically in Diagram 20. Considering the diagram as a four-fold table, this method of interpreting the results differentiates the men so that of those classed as sales engineers, 79 per cent are correctly so classed; and out of those classed as design engineers, 49 per cent are correctly so classed. The correlation between the test results treated in this way and the actual classification was $r_U = + .45$. Also, the correlation between the classification of the men by the test treated in this way and the classification of the men by the "Section II. Choice of Other Occupations" of the *Record of Interests,* was $r = +.50$. A similar and simpler method of treating the results is to transmute the raw scores into percentile ranks, and subtract the percentile rank in Part II from the percentile rank in Part I. This was done, and the classification of the engineers was practically the same; for the correlation between differences in percentile ranks (Part I minus Part II and the differences in scores in terms

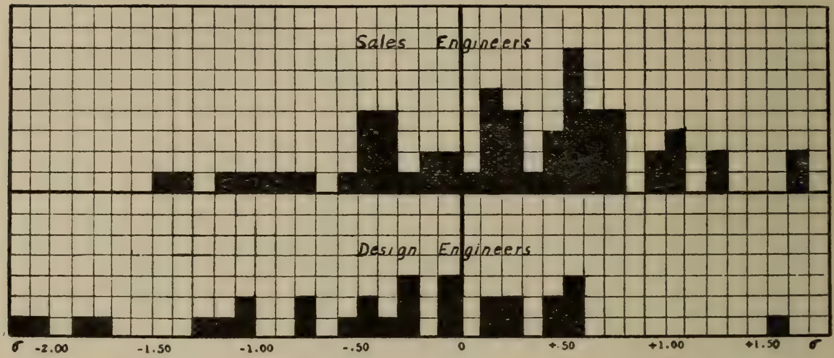

Diagram 20. Differentiation Obtained by Subtracting Scores in Part I from Scores in Part I in Terms of Standard Deviations.

Considering the diagram as a four-fold table, the engineers indicated by the test as sales engineers are 79 per cent correctly so classified; and the engineers indicated by the test as design engineers are 49 per cent correctly so classified. $r_U = + .45$.

of sigma (Part I minus Part II in terms of sigmas) was $r = +.97$.

The best method of dealing with the results is to divide the score in Part I by the score in Part II for each individual. This is the method which is the simplest, and it is the one which gives the most efficient use of the test as a means of differentiating the men. This method magnifies the differences among the individuals, which differences are shown by showing that the ability of each individual to deal with Part I differs from his ability to deal with Part II. That is, the ratio or quotient of a man's score in Part I divided by his score in Part II changes geometrically, instead of algebraically, as this man's special ability is greater or less. This probably makes the results agree more nearly with the practical considerations; for the extreme cases of special ability should be markedly differentiated. The genius is valued probably far greater than an actual measurement of capacity would indicate. The results of dealing with the scores by this method are presented graphically in Diagram 21. Consid-

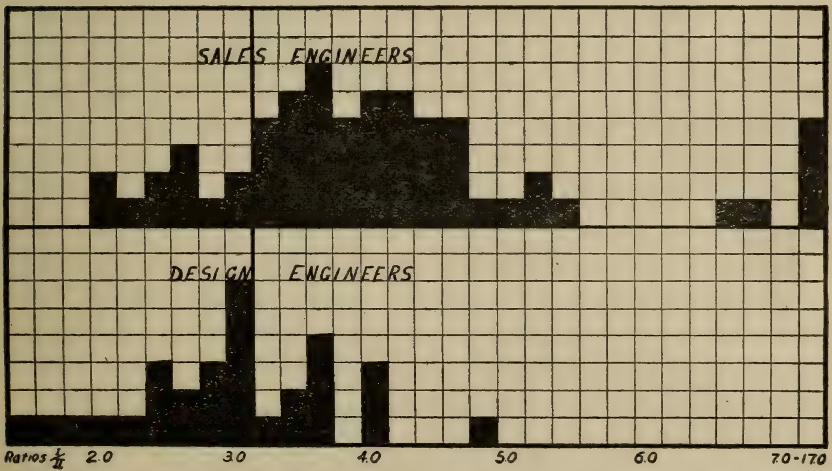

Diagram 21. Differentiation Obtained by Dividing Scores in Part I by Scores in Part II.

Considering the diagram as a four-fold table, the engineers indicated by the test as sales engineers are 81 per cent correctly so classified; and the engineers indicated by the test as design engineers are 63 per cent correctly so classified. $r_U = +.70$.

ering the diagram as a four-fold table, we have the engineers differentiated as follows:

Knowing first the actual classification of the engineers, we can say that 63 per cent of the design engineers were shown by the test to be better fitted for design engineering than 81 per cent of the sales engineers were shown to be. 81 per cent of the sales engineers were shown by the test to be better fitted for sales engineering than 63 per cent of the design engineers were shown to be. Not knowing first the classification of a group of engineers, this test can be used to differentiate them as follows: Assuming that if an engineer's score in Part I of the test is more than 3.2 times his score in Part II, he is a sales engineer, and that if his score in Part I is less than 3.2 times his score in Part II, he is a design engineer or a pure type of engineer, this test divides the engineers so that 81 per cent of those above this critical ratio (Part I at least as much as 3.2 times Part II) are sales engineers; and 63 per cent of those below it are design engineers or of a purely engineering type. (This critical ratio may be changed slightly by the change from the mimeographed form of the test to the printed form.) The correlation between the test results treated in this way and the actual classification of the men were $r_U = + .70$. Also, the correlation between the classification of the men by the test results treated in this way and the classification of the men by the *Record of Interests,* Section II, was $r = +.46$. The correlation between the marks for the engineers when the scores were treated in this way (score in Part I divided by score in Part II) and the marks for the engineers when the score in part II was subtracted from the score in Part I in terms of sigmas, was $r = +.50$. Such was the correlation coefficient obtained when the quotients (Part I divided by Part II) were correlated with differences between scores (Part I minus Part II in terms of sigmas) by the Pearson product-moment formula. However, this does not show the true relationship; for the relationship is a non-linear one; and by using the formula for *eta,* it is shown to be $\eta = .88$.

$$\eta=\frac{\Sigma}{\sigma_y}=\frac{\sqrt{\frac{S(n_x(\tilde{y}_x-\tilde{y})^2)}{N}}}{\sigma_y}$$

The second use of the test is to rank the sales engineers and the design engineers after they have been separated, so as to show who are the best design engineers, and who are the best sales engineers, considering general intelligence or all-around mental ability as well as special ability. In other words, this use of the test makes it a general intelligence or mental alertness test. The relationships of the results of the test with the estimates of the success of the engineers have already been given in the previous section. There the composite of Part I and Part II was obtained by simply adding the scores of the two parts in terms of their standard deviations. The composite does not necessarily show a higher correlation with the estimates of success than each part separately shows; for if the two parts test two widely different abilities, then combination may not give a higher correlation with the criterion. The simplest method of combining the scores is to add the percentile rank of each man in Part I to his percentile rank in Part II, and then rank the men according to these sums of percentile ranks. This gives results which are practically as reliable as those obtained by the method of combining scores in terms of sigmas.

On the basis of the results obtained so far, the test, both Part I and Part II, is being given to the graduate engineers who are entering the employ of the particular industrial firm. Only by following up these men in the lines of work which they enter later, will we finally know the value of the rating scales, of the *Record of Interests,* and of this special aptitude test.

The results already obtained on one hundred seven engineers employed by the firm during the first year that the test has been used are very similar to the results obtained on the group studied in this research. These hundred and seven men have been with the company approximately one year and they have been classified according to previous methods into sales engineers and design engineers by the executives supervising their work. The test results were not a factor in the classification. However, assuming that the executives classified the men correctly at the end of a year, we can say that the test results alone would have classified seventy per cent of the men correctly on the day that they were employed. Beginning with June, 1921, the company will use the test and other methods recommended here as definite aids in classifying and placing the graduate engineers whom they employ.

PART III. SUMMARY OF RESULTS AND CONCLUSIONS AND RECOMMENDATIONS

X. Summary of Results

The practical problem upon which we began work was to formulate methods and means based upon sound psychological principles for differentiating graduate engineers. The results of studying various existing methods and certain proposed or newly devised ones showed that some were of value and that others were not. The results might be summarized briefly as follows:

1. Technical school grades when coming from various schools of different standards, do not differentiate the men in a large group according to their ability in industry, nor according to the kind of work which they can do best. This is with the one exception that men who are selected to be design engineers are the kind of men who made higher grades in technical schools. This was true in all subjects except in general academic subjects, particularly economics, in which the design engineers fell below their own average, and the grades of the sales engineers were above their own average, so that the grades of the two groups were practically the same in these subjects.

2. Neither the grades given in the classes of the Educational Department nor the grades given in the shop on the courses of the Educational Department show any consistency or reliability. The correlation between the two sets of grades is only $r = +.19$, and the correlation is zero with all other measures such as technical school grades, ratings, and test scores. The unreliability of

these grades and ratings is doubtless due to the method of making the ratings, of recording them, and of combining them, rather than being altogether due to the inability of the foremen to make the ratings.

3. The ratings made by the foremen on the ten different traits or qualifications show no agreement with any other measures such as shop and class grades, ratings, technical school grades, or test scores. There is high intercorrelation among the traits. This is due to two causes: (a) Some of the traits are very similar, or at least they are not well enough defined for the foremen to distinguish them; and as the foremen are not trained to make such ratings, they decide that a man is either a good man or a bad man, and then rate the man accordingly either good or bad in all traits. (b) The method of making the ratings, in terms of A, B, or C, does not give the foremen any scale or basis of measure or comparison.

4. The only traits rated by the foremen which differentiate the different groups of graduate student engineers, are tact, initiative, enthusiasm, and personality. The trait called personality is the most vague and undefined, but it shows the greatest differentiation of the men; for it is a trait concerning which the foremen really get an impression and form an opinion in regard to each man.

5. The *Interviewer's Rating Scale* as already in use by the Company, has given results that have significant correlation with test scores, with later estimate of intelligence, and with technical school grades. The trait called Personal Qualities, as previously defined, had a high correlation with other traits, and was too broad, inclusive, and ambiguous to give reliable results. It was then more narrowly defined so as not to be ambiguous and not overlap or include the other traits to be rated.

6. The *College Instructor's Rating Scale* was prepared to enable the college instructors, professors, or deans to record a definite estimate of a senior on specific traits. This is expected to give more reliable and significant ratings of a man than a verbal expression of opinion of the man in general.

7. The *Shop and Class Rating Scale* was prepared to take

the place of the method of rating on ten traits by A, B, and C. It requires ratings on a few very significant traits or qualities; but it is expected to enable the foremen and the instructor to have a common understanding of just what is meant by these traits and to give a reliable and significant rating that will differentiate the engineers according to essential qualifications.

8. The use of the *Record of Interests* shows that men in different lines of work have different interests. That is, the insurance Salesmen as a group, have always had interests different from either sales engineers or design engineers. The sales engineers are men who have been more interested in economic, public, and social affairs. The design engineers are men who have been more interested in science, machinery, and actual construction or fabrication of things.

9. The engineers and the salesmen showed a definite tendency to like or be interested in occupations which in nature of work were similar to those they were already following. The kind of occupations which they thought would give them the greatest satisfaction to follow, was a significant criterion of the kind of work in which they could be and were already successful.

By computing for each engineer the percentage which his choices of occupations of a sales nature were of his total number of choices, a definite measure of his sales engineering interest as opposed to design engineering interest was obtained. By this measure, 78 per cent of the sales engineers were of a sales type; and 82 per cent of the design engineers were of an engineering type. Or assuming that we did not know the actual occupations of the engineers, those engineers which this test of interests alone would select for sales engineering, would be 89 per cent correctly placed or classified; and the men which the test of interests selected for design engineering would be 68 per cent correctly placed or classified.

10. Personnel Bureau Test VI, a general intelligence test similar to the Army Alpha intelligence test, gave results that did not differentiate the engineers according to the kinds of work for which they were thought to be fitted. The only men who had scores significantly different from the other engineers, were the

design engineers. They were a highly selected group of men who had shown ability in the engineering classes of the Company's Educational Department.

11. The general intelligence test gave scores that correlated, r = +.48, with intelligence as estimated by two executives of the Educational Department who were intimately associated with the graduate student engineers one year.

12. The general intelligence scores correlated, r = +.38, with technical school grades, and with interview ratings at the time of employment, r= +.58; but the correlations were zero with shop and class ratings, which did not correlate with any other criteria, and were evidently unreliable.

13. *Test 10, A Test for Graduate Student Engineers,* gave positive although not perfect results in separating the sales engineers from the design engineers. Knowing first the actual classification of the engineers, we can say that 63 per cent of the design engineers were shown by the test to be better fitted for design engineering than 81 per cent of the sales engineers were shown to be. 81 per cent of the sales engineers were shown by the test to be better fitted for sales engineering than 63 per cent of the design engineers were shown to be. Not knowing first the classification of a group of engineers, this test can be used to differentiate then as follows: Assuming that if an engineer's score in Part I of the test is more than 3.2 times his score in Part II, he is a sales engineer, and that if his score in Part I is less than 3.2 times his score in Part II, he is a design engineer or of a pure engineering type, this test divides the engineers so that 81 per cent of those above this critical ratio (Part I 3.2 times Part II) are sales engineers, and 63 per cent of those below it are design engineers or of a purely engineering type. (This critical score may be changed slightly by a change from the mimeographed form of the test to the printed form.)

14. The differentiation of the engineers resulting from the use of Test 10 showed a comparatively high correlation with the results of the *Record of Interests.* The correlation was r = +.50 when the scores in Part II were subtracted from those in Part I in terms of sigmas. The correlation was r = +.46

when the differentiation was obtained by dividing the scores in Part I by the scores in Part II. This shows not only that there is high correlation between interest and special ability, but also that the Record of Interests and Test 10 give reliable results.

15. Test 10 used as a general intelligence or mental alertness test for sales engineers gave scores that correlated, $r = +.86$ and $+.81$ with estimated success. The same test used as a general intelligence test for design engineers gave scores that correlated, $r = +.22$ and $+.59$, with estimated success.

XI. Conclusions and General Principles Derived from the Study

1. The study of the technical school grades show that such grades cannot be made of practical use to differentiate engineers for various kinds of work, except in a very general way. Sales engineers do comparatively better in economics than in engineering subjects. The design engineers make much lower grades in economics than they do in mathematics and science, engineering, and shop.

2. When foremen are asked to rate men under them on a large number of traits which are not carefully defined, the ratings are unreliable and of little use as a measure of the value of the men rated; and such ratings are particularly of no use for classifying the men and placing them in positions for which they are best fitted. Generalizing, we can say that ratings made by different people on traits which are understood by some to be one thing and by others to be another, are of no value. This difficulty arises if the traits are not carefully defined in terms that the raters can understand; and there is the same difficulty if there are many traits to be rated, some of which overlap or include others so that they can not be differentiated. The ratings are unreliable if there is no scale or standard with which the men can be compared. This basis of comparison may be the other men of the same group; but there must be definite comparison instead of arbitrary grades or marks. Finally, the ratings or marks must be recorded in such a form that they can be readily tabulated and actually used in placing the men.

4. Carefully prepared acquaintance-comparison rating scales, such as the *Interviewer's Rating Scale* and the *Shop and Class Rating Scale,* give much more reliable results than forms on which arbitrary grades or marks are recorded opposite certain names of traits. The acquaintance-comparison rating scale enables the rater to compare the one to be rated with other people as concrete examples of different grades of the same trait.

5. The use of the *Record of Interests* shows that men in different lines of work have different interests. The interests of a person are not in just one specific occupation, but they are general to the extent that they pertain to very similar or closely allied occupations or activities. Interest in a certain class of activities is a criterion that the person will be interested in any other very similar activity. By similar activity is meant one that requires much the same information, training, experience, kind of materials and tools worked with, mental activity, personality, ideals of accuracy and perfection, and social attitude.

6. In the engineering profession, men cannot be differentiated for different lines of work by tests which measure what is commonly known as general intelligence or mental alertness. Men in the same kind of engineering work differ in this intelligence as greatly as men in *different* kinds of engineering work. The differences which fit these men for different kinds of work, are something other than differences in intelligence.

7. General intelligence as measured by a general intelligence test does show a significant positive correlation with the success of engineers in the same kind of work.

8. One man differs from another in having special abilities, which functioning in an integrated form as a kind of intelligence, can be measured and used as criteria for placing the man in the kind of work for which he is best fitted.

9. The occupational interests of a man show a definite correlation with the kind of intelligence or special abilities which he has, and with the kind of occupation in which he is successful.

XII. Specific Methods and Practices Recommended

1. Before senior engineers who are being graduated from the technical schools, are employed, they should be rated by the use of rating scales. The representatives of the Company who interview the seniors, should use the *Interviewer's Rating Scale*. Before the interviewers start on their visits to the colleges, they should carefully make a *Master Rating Scale* from the list of engineers whom they know intimately and who have passed through the Educational Department within the previous five years. If possible, two or three interviewers representing the Company should interview the senior and make ratings independently, and then combine the ratings later.

2. After the interviewers have returned to the home office and have prepared a large tentative list of seniors who are to be considered for employment, the name of each senior should be put on a blank *College Instructor's Rating Scale*, and this blank sent to the dean, professor, or instructor who can be depended upon to give a reliable rating of the man under consideration. A rating by more than one instructor is desirable if it can be obtained without imposing on the instructors. Most of the professors are glad to help place their students. If the representative believes that the senior will be desired by the Company and that this senior will make application, he should get the rating from the professor while visiting the college or as soon as possible.

3. As soon as the graduate student engineers enter the Educational Department of the Company, they should be under observation in the shop and in the class to be rated at the end of each month by means of the *Shop and Class Rating Scale*.

4. Within the first two months after the graduate student engineer enters the Educational Department of the Company, he should be given the *Test 10, A Test for Graduate Student Engineers*. This should be scored, first to determine for what kind of work the engineer is probably best fitted; second, to determine what the rank in general intelligence is.

5. At the end of two months or just before it is necessary to segregate the graduate student engineers for intensive training in

some particular line of work, the student engineers should be requested to fill out the blank entitled *Rceord of Interests.*

6. At the end of two months or when it is necessary to know into what line of work the student engineers are going, the results of the rating scales, the test, and the *Record of Interests,* should be combined. The impressions and opinions concerning the engineers which the executives, interviewers, and instructors of the Educational Department have recorded on the rating scales, should have a weight or vote of one-third in the final composite measure of the men; the test should have a vote or weight of one-third; and the *Record of Interests* should have a weight or vote of one-third to determine for what line of work the engineer should be recommended. In case of doubt, any two of these measures or criteria should determine for what work the particular man should be recommended. Of course the judgments of the executives concerned will be the final criteria, but their impressions and opinions should be based upon dependable data and be corrected by this data.

7. The student engineer should be interviewed with his *Record of Interests* before him and the interviewer; and in the interview the student should be advised to enter the line of work for which he is best fitted as determined by this *Record of Interests,* the test, and the rating scales. This advice should be given as an intelligent recommendation; but the student should not be urged against his will to enter a particular line of work. If the student objects to the recommendation, it should be discussed in the light of the results of the *Record of Interests* and of *the test.*

8. After the student engineers have been segregated and assigned tentatively to their respective lines of work, a copy of the Record of Interests and the results of the test should be transmitted to the heads of the respective departments in which the men will work.

9. The results of all rating scales, tests, and *Record of Interests,* should be carefully recorded and filed; and the later success or record of the engineers should be systematically followed

up in order to check the reliability and value of the methods and means of selection, classification, and placement being used.

10. Some person qualified for personnel research work should be assigned the responsibility for keeping rating scales and tests in proper use, working up the results, carrying on the research and follow-up work, and planning and directing new lines of research which should be undertaken to increase the efficiency of the educational, placement, and other personnel work.

11. The rating scales, tests, and *Record of Interests* should be studied to make further improvements as a result of their use. A duplicate or alternate form of the test should be prepared, which could be given in case there is reason to believe there has been coaching for the first form.

12. In the light of results obtained in the study of this problem with graduate student engineers, research work in personnel problems should be extended to the apprentices, the clerical workers and the shop employees of the Company.

BIBLIOGRAPHY

Benge, E. J. Standard Personnel Practice. H. W. Wilson Co., New York. 1920.

Bingham, W. V. Army Personnel Work. *Journal of Applied Psychology,* March, 1919, vol. 2, pp. 1-12.

Frankel, L. K., and Fleischer, A. The Human Factor in Industry. Macmillan Co. 1920.

Committee on Classification of Personnel. The Personnel System of the United States Army. Vol. I, History of the Personnel System. Vol. II, The Personnel Manual. Superintendent of Public Documents, Washington, D. C. 1920.

Hollingworth, H. L. Vocational Psychology. D. Appleton & Co. 1916.

Kitson, H. D. Interest as a Criterion in Vocational Guidance. *Educational Review,* vol. 24, pp. 207-214, March, 1916.

Link, Henry C. Employment Psychology. Macmillan Co. New York. 1919.

Mann, Charles R. A Study of Engineering Education. Bulletin No. 11, Carnegie Foundation, 576 Fifth Avenue, New York. 1918.

Moore, Bruce V. General Intelligence Determined by Its Weakest Essential Element. *Journal of Applied Psychology,* vol. 4, pp. 151-161. June-Sept., 1920.

Scott, W. D. Changes in Some of Our Conceptions and Practices in Personnel. *Psychological Review,* 1920, No. 27, pp. 81-94.

Scott, W. D. A Fourth Method of Checking Results in Vocational Selection. *Journal of Applied Psychology,* March, 1917, vol. 1, pp. 61-66.

Tead, O., and Metcalfe, H. C. Personnel Administration. McGraw-Hill. New York. 1920.

Thorndike, E. L. The Permanence of Interests and Their Relation to Abilities. *Popular Science Monthly,* vol. 81, pp. 449-456. December, 1912.

Thurstone, L. L. Mental Tests for Engineering Students. *Proceedings of the Society for the Promotion of Engineering Education,* vol. 27, 1919, pp. 113-119.

Yoakum, C. S., and Yerkes, R. M. Army Mental Tests. Henry Holt Co., New York. 1920.

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The Interrelation of Some Higher Learning Processes

BY

B. F. HAUGHT, Ph.D.
Associate Professor of Psychology, State University of New Mexico

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FOREWORD

The writer is greatly indebted to Dr. Joseph Peterson whose guidance and personal interest have been of inestimable value throughout the conduct of this investigation and whose scientific attitude has been a source of great inspiration. He also wishes to take this opportunity to express his thanks and appreciation to the students who served patiently as subjects to make the investigation possible, and especially to his wife who assisted greatly in making the mathematical calculations.

ERRATA

Attention is directed to the following list of corrections of errors, which unfortunately were not remarked in time to be set right in the body of the text:

In Table VIII, p. 21, "100-19," lower left corner, should read "0-19." "50-64" in top row should read "60-64."

In Table X, p. 23, "0-10" in top row should read "0-19."

In Table XV, p. 31, the omitted spaces in the base line should be 6 and 8, respectively, from left to right; and "20-25" in the top row should read "20-24."

In Table XVI, p. 32, "(Modified)" should be added at the end of the line just over the figure, beginning "X = ."

In Table XVII, p. 33, numbers omitted in lower row should be, from left to right: 3, 2, 3, 5, 7, 8, 9, 9, 7, 6, 7, 3, 3, and 2.

In Table XXII, p. 41, "54-60" in first column should read "64-60;" and "35-35" in the top row should read "35-39."

In Table XXV, p. 47, 7 and 17 in the 9th and the 10th squares of the bottom row should be 11 and 13, respectively.

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THE INTERRELATION OF SOME HIGHER LEARNING PROCESSES

I. Problem

The purpose of this investigation is to analyze and to study the interrelations of some higher mental processes. Each of the experiments used involves two or more factors,[1] such as time, repetitions, solutions, errors, etc. Each problem requires considerable time for the learning and in this respect is different from the individual parts of most intelligence tests. The problems are also of such a nature that the subject may solve them either by the hit-and-miss method or by a reflective method. In every case it is possible to record all the responses of the subject, and thus provide objective data for the analysis.

The purpose is to compare each factor in the tests with a criterion and with every other factor. The tests will be scored by combining the significant factors and they will then be further compared with the criterion and with each other. In this way it is believed that a detailed analysis can be made that will throw light on methods of learning and on the characteristics of tests involving the higher mental processes. This procedure will analyze not only the tests used, but also the criterion. An attempt will be made to answer such questions as the following: Does time measure any elements in learning that are not measured by the criterion? Does time measure any elements in learning that are not measured by repetitions or errors? Does one rational learning experiment involve the same functions as any other? Is there a general rational learning function, or are such types of learning simply operations of various factors in different sorts of combinations.

---

[1] Factor is used in this investigation to designate one kind of data, such as time, repetitions, solutions, errors, etc.

II. METHOD

The raw scores in each experiment are first put into percentiles by use of Rugg's table.[2] In order to shorten the work a table based on seventy-four cases, the number used in this investigation, was constructed. Three steps are involved in making such a table. First, the numbers from 1 to 74 are divided by 74, giving the percent of subjects making each score. Second, since Rugg's table provides for the percent failing, it is necessary to subtract each of these percents from 100, getting the percent below each score. Third, the percentile[3] corresponding to each number obtained in the second step is taken from the table. An illustration will serve to make the method clearer. We shall take the subject making the highest score. He ranks number 1. This number divided by 74 gives 1.35 percent. If we subtract 1.35 from 100, we get 98.65, the percent of subjects below the best one. The percentile in the table corresponding to 98.65 is 86. Then 86 is the percentile rank of the subject having the highest rank in any test or factor of a test. The corresponding percentiles are found in this manner for each rank and then it is necessary only to rank the subjects by the usual method and read off the percentiles from the table.

There may be a slight objection to this method of assigning percentiles. The question may well be asked as to why the scores run down to 0 and yet up only to 86. Why should they not go up to 100? By this method the upper score will approach 100 as the number of cases is increased. If we think of the scale as a continuous one, we may regard 0 as extending from 0 to 14 and 86 as extending from 86 to 100. It would probably have been a little more correct to have moved each score up a half step or to have designated its middle position in a continuous scale. This would have put the lowest scale at 7 and the highest at 93. Certainly there would have been no difference in the results as far as correlations are concerned. It would have thrown the mean in each distribution just a small fraction of a unit higher and would not have changed the standard deviations.

---

[2] Rugg, H. O., *Statistical Method Applied to Education,* 1917, 396 ff.

[3] Scores are assumed to fit the probability curve and percentages of subjects who make various scores correspond to percentages of area under the curve from the 0 point to a point on the base line. This point on base line is measured in units of σ and is transformed into percentile scores by setting 0 at $-3.0\ \sigma$, 50 at the mean and 100 at $+3.0\ \sigma$.

Example: A subject having 20 per cent of the subjects below him will always have a percentile score of 36.

The reason for not using the raw scores probably needs no defense here. The percentiles as used here tend to give a more nearly normal distribution than that given by the raw scores. Nearly all devices for handling and refining data are based on normal distribution. Probably scores that give a normal distribution are more nearly correct than raw scores. Who knows whether five minutes consumed at the beginning of the experiment is just as significant as five minutes after the subject has been working thirty minutes? Again, is there any evidence that two hundred errors mean just half as much efficiency as one hundred? Very often one little confusion or distraction will cause the number of errors to be doubled. A second reason may be given for using the percentiles. All standard deviation units are, for all practical purposes, equal[4] and thus simplify analysis by the use of regression lines. The regression of x on y will always be equal to y on x when the standard deviations of the two arrays are equal. Also in the distribution tables the number of rows will be equal to the number of columns and thus make the regression lines less likely to be misinterpreted.

After the data have all been reduced to percentiles, the next problem is to determine the method of scoring or combining the different factors in the test. This method of scoring is secondary to that of analysis. Such questions as the following must be answered: Is it necessary to use all the factors in the tests? If not, what ones should be used? The answers to such questions are important from both the standpoint of scoring and from that of analysis. The answer will be sought by using the scores in the Binet-Simon Tests[5] as a criterion and then using partial correlations.

---

[4] The lowest standard deviation is 15.56 and the highest 16.68. The exact standard deviation for each factor and test will be given later.

[5] Whenever the expression, "Binet-Simon Tests" is used, the Stanford Revision is meant.

Some objections could be raised to this method of procedure. The first one is the criterion itself. Does it include all factors in tests that have value? Does it include these in such a proportion that the scores are the best ones? No attempt will be made to answer these questions at this stage. From the point of view of this study, these are not such important questions, since the criterion as well as the experiments will be analyzed. In other words these are questions that should be answered after the experiments have been analyzed. The scores resulting from the combination of factors will have no value other than for analysis as far as this investigation is concerned. The tests have some other serious defects. Only those will be mentioned that apply to adults, since this investigation is limited entirely to this field. It is claimed that the Binet-Simon tests fail to distribute individuals in the upper quartile widely enough. In other words, the tests are too easy for very bright adults. The highest intelligence quotient possible is 122. Some of the individuals were not measured accurately. This is a serious objection to the tests themselves. For this study, however, it is not so serious as it would be where the object was to determine the actual intelligence quotients. It is true that the intelligence quotients have been used, but only the ranking of them was used in determining the percentiles. It is reasonable to expect that the ranking of the subjects by intelligence quotients is much more nearly correct than the absolute intelligence quotients themselves. Another objection is that the tests are not standardized for the upper years. This objection does not interfere in the present cases, since it is only the ranking of the subjects in intelligence quotients that is used, and since only one of the subjects made the highest score possible.

Other criteria could have been used. The school grades in the various subjects could have been combined and used. This was done by Rosenow.[6] That scheme, however, would not have worked very well in this case, since the subjects had different teachers during the year and there was no standard to unify the grading. There are other reasons why academic marks are not good for a criterion. Too many other factors, such as health, outside attractions, interest in the subject, etc., which are very often not known by the teacher, enter into the grades of the students. The school grade is certainly not as significant as the Binet-Simon tests in determining intelligence. This fact has already been pointed out by psychologists.[7] Another criterion that is regarded as sound by some is the combined judgment of instructors.[8] This, however, has its limitations, especially for the present study, where no instructors could be selected who were acquainted with all the subjects. This, as has been shown by Thorndike,[9] is not an unsurmountable difficulty. Taking everything into consideration, however, there probably is no one thing that would make a better criterion than the Binet-Simon tests. This criterion could have been made much better if it had been supplemented with other tests and the combined results used. The Otis tests could have been given and the intelligence quotients combined with those in our criterion. This, however, was not thought of until it was too late to get the tests and administer them.

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[6] Rosenow, Curt, The Analysis of Mental Functions, *Psychol. Monog.*, 1917, *24* (No. 106).

The second objection to this procedure is that it assumes linearity. It is claimed by some that correlations are meaningless when non-linearity exists. Rosenow[10] has given the best rebuttal to this argument that has come to the writer's notice. He says: "It follows that, taken merely as an indication that an actual relation does exist between two variables, r, the coefficient of correlation, is actually entitled to increased confidence if non-linear regression is shown. Indeed the mere proof of non-linear regression is in and of itself proof of the existence of a true relation, and also of the fact that it is greater than indicated by r. It can hardly be claimed that a positive assertion which errs only on the conservative is meaningless. As a special case we may note that r=0 does not necessarily indicate the absence of relation." Again he says: "The subject of non-linear regression for the psychologist amounts simply to this. If he is investigating the relation of two variables to each other he can get nearest the truth by 'fitting' a curve and determining its equation. Even in that case useful results are practically always obtainable by assuming linearity. But if one is dealing with a complex situation the only practical possibility with our present technique is to assume linearity. The results, when properly interpreted, will *not* be meaningless."

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[7] *E. g.*, Peterson, Joseph, The Rational Learning Test Applied to Eighty-one College Students, *J. of Educ. Psychol.*, 1920, *11*, 137 ff.

[8] Ruml, Beardsley, The Reliability of Mental Tests in the Division of An Academic Group, *Psychol. Monog.*, 1917, *24* (No. 105).

[9] Thorndike, E. L., Combining Incomplete Judgments of Relative Position, *J. Phil. Psychol. and Sc. Methods*, 1916, *13*, 197 ff.

[10] Rosenow, Curt, The Analysis of Mental Functions, *Psychol. Monog.*, 1917, *24*, (No. 106), 10 f.

In this investigation linearity will be assumed for the purpose of calculating correlations and combining factors, but interpretations will be made in such a way as to make allowance for all cases of non-linearity. That is, the degree of non-linearity, as shown by an inspection of the curves through the means of the rows and columns, will be noted in each case.

After the factors in the tests have been analyzed in the light of the criterion, the investigation will be carried further by the use of multiple correlation. This may be done directly from the equation,[11]

$$R^2_{1(23456)} = 1-(1-r^2_{12})\,(1-r^2_{13.2})\,(1-r^2_{14.23})\,(1-r^2_{15.234})\,(1-r^2_{16.2345}) \qquad (1)$$

in which R is the symbol for the correlation between the criterion 1 and the factors 2, 3, 4, 5, and 6 combined in such a way as to give the highest correlation possible. It is possible by the use of this formula to determine what factors are necessary to get the highest correlation. If some factors are shown by partial correlations to have nothing in common with the criterion except what is contained in other factors and then the formula for multiple correlation shows that the correlation with the criterion is not reduced by discarding these factors, there is no reason for using them.

[11] Yule, G. U., *Introduction to The Theory of Statistics*, 248 ff.

Now that it has been decided just what factors should be used, the next step is to determine the best combination of them. Must they be combined in equal proportion or in some other ratio? To determine this question, the following formula will be used:

$$C = \frac{\sigma_M (r_{IM} r_{Mm} - r \quad)}{\sigma_m (r_{Im} r_{Mm} - r_{IM})} \qquad (2)$$

in which M is the major factor, m the minor factor, I the criterion and C a constant which determines how m shall be weighted in order to give the highest correlation with I when combined with M. In order to find this highest correlation after C has been determined, the following formula will be used:

$$r_{I(M+Cm)} = \frac{r_{IM}\sigma M + C r_{Im} \sigma m}{\sqrt{\sigma M^2 + 2 C r_{Mm} \sigma M \sigma m + C^2 \sigma m^2}} \qquad (3)$$

in which the letters have the same meaning as in formula[12] (2). If more than two factors need to be combined in any test, two will be combined in the best way and then this result with the third factor. In this way any number of factors or tests may be combined.

The method of scoring will then consist of four steps: first, the determination of the significant factors by multiple and partial correlation; second, the finding of the best combination of the significant factors; third, the determination of the best correlation when this combination is used; fourth, actually combining the factors and working out the correlation to test the reliability of the mathematical work.

Each factor will be further analyzed by stating the theoretical relation to the criterion and the actual relation in terms of the curves of the means of the columns and of the rows. The tables of partial correlations will be freely used in determining the relation of each factor to the criterion and to the other factors. For example, an attempt will be made to find the relation of the time factor to the criterion and then to the other factors of repetitions and errors. Special cases that fall below the fortieth percentile in one test and above the sixtieth in another will be analyzed as far as objective data will permit.

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[12] For the development of these formulae, see Thurstone, L. L., A Scoring Method for Mental Tests, *Psychol. Bull.*, 1919, *16*, 235 ff.

III. SUBJECTS

Eighty college students were tested in securing the data for this investigation. All were in the same course, conducted by the writer in the winter and spring terms of the school year 1919-20. The testing began early in January and continued until the first week in June. The course was conducted in three sections. One section was begun the first week in January and finished on the twenty-fifth of March. The other two were begun the last week in March and finished on the ninth of June. Six of the subjects tested are not included in the final list of seventy-four because of having failed to take all the tests or because of having been coached in one of the tests. A record of the sex and college class is given in Table I for each subject.

In many respects this represents a selected group. There is considerable uniformity in age, education, and social status. The majority are high school graduates, and those who are not have in some other kind of school completed work sufficient for college entrance. There are three or four in the group who have very low intelligence. These have browsed around here and there, gaining a few credits at each place, until they were able to get freshman standing in a college, but are not able to do real college work. No attempt was made to select subjects for the investigation. The aim was to use all who entered a certain class in education. This was followed as nearly as possible, the only exception being in the case of six students, of whom four left school before all the tests were taken and two showed evidence of having been coached on one of the experiments.

IV. THE BINET-SIMON TESTS (*Stanford Revision*)

In every instance the subject was first given the tests for the average adult. If he passed on all of them he was then given the tests for the superior adult; but if he failed on one or more of

TABLE I. Showing Sex and College Class of Each Subject.

Subject[13]	Sex	College Class	Subject	Sex	College Class
1	f	Freshman	38	f	Freshman
2	f	“	39	m	“
3	m	“	40	f	Sophomore
4	f	“	41	f	Senior
5	m	Sophomore	42	f	Sophomore
5	f	Freshman	43	f	Freshman
7	f	“	44	f	“
8	m	“	45	m	“
9	f	“	46	m	Sophomore
10	m	“	47	f	Freshman
11	f	“	48	f	“
12	m	“	49	f	Sophomore
13	f	“	50	f	Freshman
14	m	“	51	m	“
15	f	“	52	f	“
16	f	“	53	f	“
17	m	“	54	f	“
18	f	“	55	f	“
19	f	Senior	56	m	“
20	f	Freshman	57	f	“
21	f	“	58	f	“
22	f	Sophomore	59	f	Sophomore
23	f	Freshman	60	f	Freshman
24	f	“	61	f	“
25	f	“	62	f	“
26	f	“	63	f	“
27	f	“	64	f	“
28	f	Sophomore	65	f	“
29	f	Junior	66	m	Freshman
30	f	Freshman	67	f	Sophomore
31	f	Sophomore	68	m	“
32	f	“	69	f	“
33	m	Freshman	70	f	Freshman
34	m	“	71	f	“
35	f	Sophomore	72	f	“
36	f	Freshman	73	f	“
37	f	“	74	f	“

TABLE II. Showing Summary of Subjects.

	Freshman	Sophomore	Junior	Senior	Totals
Male	13	3	0	0	16
Female	44	11	1	2	58
Totals	57	14	1	2	74

---

[13] The numbers assigned to the several subjects in this table will be used in all following tables.

them he was then given the tests for fourteen years of age. In case all the tests in this year were not passed, the twelve year tests were given. In no case was it necessary to go further back and in very few back so far. If the subject did one or more of the tests for the average adult correctly, he was given the tests for the superior adult also. The mental age and the intelligence quotient were found for each subject in the manner suggested by Terman.[14] Table III gives the intelligence quotient and the percentile rank for each subject.

TABLE III. Showing Intelligence Quotient and Percentile Rank for Each Subject in the Binet-Simon Tests.

Subject	Intelligence Quotient	Percentile Rank	Subject	Intelligence Quotient	Percentile Rank
1	113	69	38	82	21
2	116	78	39	110	63
3	98	42	40	96	39
4	106	54	41	107	58
5	122	86	42	109	60
6	91	30	43	94	35
7	104	52	44	95	37
8	76	0	45	99	45
9	80	18	46	110	63
10	91	30	47	102	49
11	113	69	48	101	47
12	99	45	49	110	63
13	95	37	50	103	51
14	96	39	51	98	42
15	106	54	52	107	58
16	106	54	53	93	34
17	83	23	54	101	47
18	105	53	55	101	47
19	113	69	56	98	42
20	96	39	57	104	52
21	92	32	58	110	63
22	95	37	59	101	47
23	98	42	60	78	14
24	116	78	61	116	78
25	98	42	62	113	69
26	110	63	63	113	69
27	99	45	64	103	51
28	101	47	65	107	58
29	104	52	66	113	69
30	102	49	67	107	58
31	107	58	68	113	69
32	93	34	69	107	58
33	87	27	70	116	78
34	113	69	71	85	25
35	99	45	72	110	63
36	93	34	73	104	52
37	109	60	74	91	30

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[14] Terman, *The Measurement of Intelligence,* 1916.

V. THE RATIONAL LEARNING TEST

(1) Description of Test and Method of Scoring.

In this test the procedure of the author[15] was followed as nearly as possible. The instructions to the subject and the method of recording the data were identical. Some variations occur in the scoring, as will appear later. The instructions to the subject follow:

"This is a memory-reason test. The letters A, B, C, D, E, F, G, H, I and J are numbered in a random order from 1 to 10. I call out the letters in their order and you are to guess for each letter till you get the correct number, when I say 'Right.' Then I call out the next letter, and so on. This is continued until you get each number right the first guess twice in succession through the series, from A to J. Then you are through. You must ask no questions, but are to use all the mental powers at your command. You will be judged by (1) the total time you take, (2) the number of errors or wrong guesses you make (every number you speak being a guess), and (3) the number of repetitions from A to J that you require for the learning. Re-read these instructions carefully, if necessary, to understand what you are to do. The meaning will be clearer as we go on with the experiment."

The subject was seated at a table opposite the experimenter and shielded from the latter by a screen. He was given a typewritten copy of the instructions and allowed to read and study them until he was ready to go on with the learning. He usually consumed about one minute. When the subject said he was ready to proceed, a stop watch was started, the letters called out in their order, and the responses recorded as shown in Table IV. When the learning was complete, the total time was recorded and the subject asked to write as much as he could about how he learned to repeat the numbers in order.

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[15] Peterson, Joseph, Experiments in Rational Learning, *Psychol. Rev.*, 1918, *25*, 433 ff.

Table IV. Showing Record of Subject Number 68 and Method of Recording Data.

Letters	A	B	C	D	E	F	G	H	I	J	Errors			
Numbers	6	4	9	1	8	10	3	2	7	5	Uc.	†	*	Total
First Repetition	6	3 5 9 8 7 4	1 3 2 5 6† 7 8 9	10 8 7 5 3 2 1	2 3 5 7 8	2 3 5 7 8† 10	2 3	2	9† 7	5	29	3	0	32
Second Repetition	6	4	9	2 1	8	3 4† 5 2 7 8† 9† 5* 10	3	8† 7 3† 2	3† 5 7	3† 5	15	7	1	23
Third Repetition	6	4	9	1	10 8	9† 2 3 7 8† *9† 10	7 8† 2 1† 3	7 9† 2	7	5	13	6	1	20
Fourth Repetition	6	4	9	1	10 8	2 7 8† 9† 10	3	2	7	5	5	2	0	7
Fifth Repetition	6	4	8 9	1	10 8	2	3	2	7	5	2	0	0	1
Sixth Repetition	6	4	9	1	10 8	10	3	2	7	5	1	0	0	1
Seventh Repetition	6	4	9	1	8	10	3	2	7	5	0	0	0	0
Eighth Repetition	6	4	9	1	8	10	3	2	7	5	0	0	0	0
Totals											65	18	2	85

Three schedules of numbers were used in giving this test. Subjects 12, 15, 20, 21, 22, 25, 31, 34, 35, 37, 39, 40, 44, 47, 49, 52, 53, 54, 57, 59, 62, 66, 67, 68, 69, and 74 used schedule 1.[16] Subjects 1, 2, 5, 6, 7, 8, 10, 13, 14, 17, 18, 19, 28, 29, 30, 36, 38, 50, 55, 56, 60, 63, 70, 72, and 73 used schedule 2.[17] Subjects 3, 4, 9, 11, 16, 23, 24, 26, 27, 32, 33, 41, 42, 43, 45, 46, 48, 51, 58, 61, 64, 65 and 71 used schedule 3.[18]

The numbers were arranged according to no special method. Schedule 2 is that used by Dr. Peterson[19] in some of his work. Schedules 1 and 3 were made with the idea of having them equal in difficulty to 2. This, of course, makes the statement as to random numbering in the directions to the subject slightly incorrect, but each schedule could be obtained by a random selection. Therefore the statement should put the subject to no disadvantage. From observation there is no difference in the difficulty of the schedules. The orders 3-2, 5-4, and 6-5 in schedules 1, 2, and 3 respectively present especial difficulty to many subjects. The purpose in having different schedules was to reduce probability of coaching. There was no evidence of coaching in this test. Each subject was asked after the test was performed not to tell any other member of the class anything that might assist in the learning.

The column headed Uc. in this table gives the unclassified errors, or the total number of errors regardless of kind.

Errors marked † are called logical errors. They are errors which consist in guessing a number that has already been used for an earlier letter of the series, one that could, therefore, not possibly be right.

Errors marked * are called perseverative errors. They are errors which consist in repeating a wrong guess while reacting to a single letter.

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[16] Schedule 1	A	B	C	D	E	F	G	H	I	J
	6	4	9	1	8	10	3	2	7	5
[17] Schedule 2	A	B	C	D	E	F	G	H	I	J
	9	6	2	10	8	1	5	4	7	3
[18] Schedule 3	A	B	C	D	E	F	G	H	I	J
	4	8	3	1	9	7	10	6	5	2

[19] Peterson, Joseph, Experiments in Rational Learning, *Psychol. Rev.*, 1918, 25, 433 ff.

In Table V are given the raw scores of all the subjects, and also, on the right hand side of the table, the scores converted into percentile rank and the final combined score. This combined score for the test is determined by combining the percentile rank in repetitions and in perseverative errors and then converting into percentile score from Rugg's table, as will presently be explained. Tables VI and VII show, respectively, the total and the partial correlations of each factor in the Rational Learning Test with the criterion, the Binet-Simon tests, and the total and the partial correlations of the factors in the Rational Learning Test.

TABLE V. Showing the Number of Minutes†, the Number of Repetitions, the Number of Each Kind of Errors, and the Percentile Rank for Each Kind of Data in Rational Learning.

	Raw Score in					Percentile Rank in					
Subject	Time	Rep.	Uc.E.	L.E.	P.E.	Time	Rep.	Uc.E.	L.E.	P.E.	Score‡
1	3	4	27	0	0	86	76	72	82	71	78
2	17	8	124	64	3	42	46	35	30	55	52
3	14	7	96	34	13	46	53	42	45	35	40
4	18	8	71	8	3	40	46	50	63	55	52
5	5	4	56	23	0	74	76	57	49	71	78
6	6	3	23	0	0	72	85	76	82	71	84
7	17	11	64	13	1	42	35	53	57	63	49
8	21	14	196	78	38	31	25	21	21	23	18
9	12	7	21	2	0	53	53	79	73	71	65
10	19	11	113	34	15	36	35	37	45	28	28
11	18	9	47	10	3	40	42	61	59	55	48
12	20	14	240	143	12	33	25	18	18	38	28
13	7	5	59	13	4	69	68	55	57	51	61
14	20	11	168	66	3	33	35	28	28	65	44
15	16	6	53	28	3	44	61	59	47	55	59
16	7	4	44	6	4	69	76	65	66	51	68
17	25	15	169	72	11	25	16	27	23	40	22
18	14	9	81	28	5	46	42	46	47	48	44
19	9	7	93	38	7	61	53	43	42	45	49
20	13	10	62	18	5	49	38	54	53	48	38
21	12	9	79	42	3	53	42	46	38	55	48
22	8	6	105	44	6	65	61	40	35	46	56
23	18	12	130	58	0	40	31	31	32	71	53
24	8	8	43	9	2	65	46	65	61	59	56
25	17	14	109	31	3	42	25	39	46	55	36
26	16	10	88	34	17	24	38	45	45	25	28
27	12	7	88	35	4	53	53	45	43	51	54
28	12	7	53	16	0	53	53	59	54	71	65
29	14	7	75	21	6	46	53	48	50	46	51
30	10	6	35	1	4	59	61	69	76	51	58
31	33	14	110	36	13	0	25	38	43	35	25
32	12	7	72	40	2	53	53	49	40	59	59

TABLE V (Continued)

Subject	Raw Score in					Percentile Rank in					Score‡
	Time	Rep.	Uc.E.	L.E.	P.E.	Time	Rep.	Uc.E.	L.E.	P.E.	
33	18	12	116	38	11	40	31	36	42	40	34
34	13	13	129	41	2	49	28	32	38	59	40
35	10	5	45	5	2	59	68	63	68	58	68
36	19	7	87	36	13	36	53	45	43	35	40
37	8	8	47	9	0	65	46	61	61	71	60
38	30	11	178	71	13	18	35	23	25	35	33
39	5	3	23	4	0	74	85	76	71	71	84
40	11	6	75	23	10	57	61	48	49	40	52
41	9	5	41	7	0	61	68	67	65	71	73
42	20	12	174	54	13	33	31	25	33	35	32
43	11	6	38	10	1	57	61	68	59	63	65
44	17	8	106	20	10	42	46	40	51	40	38
45	19	6	65	19	12	36	61	52	52	38	51
46	13	5	48	13	3	49	68	60	57	55	62
47	22	9	126	47	28	29	42	33	35	23	31
48	12	9	62	7	5	53	42	54	65	48	44
49	9	5	44	14	2	61	68	65	56	59	68
50	19	10	146	43	35	36	38	30	36	18	22
51	24	9	111	42	14	27	42	38	38	31	35
52	12	7	55	10	4	53	53	58	59	51	54
53	11	9	90	40	8	57	42	43	40	44	38
54	13	8	56	12	5	49	46	57	58	48	45
55	19	9	98	59	5	36	42	41	31	48	44
56	32	15	463	267	73	14	16	0	0	0	0
57	26	21	398	206	28	23	0	14	14	23	14
58	10	7	59	18	9	59	53	55	53	42	46
59	15	8	97	48	9	45	46	42	34	42	40
60	7	8	24	5	0	69	46	73	68	71	60
61	14	5	72	23	9	46	68	49	49	42	57
62	8	6	45	7	1	65	61	63	65	63	65
63	4	6	29	5	0	82	61	70	68	71	70
64	8	7	41	4	0	65	53	67	71	71	65
65	5	5	17	0	0	74	68	86	82	71	73
66	11	6	69	19	2	57	61	51	52	59	61
67	14	11	124	68	9	46	35	35	27	42	35
68	8	8	65	18	2	65	46	52	53	59	56
69	12	7	70	14	8	53	53	51	56	44	48
70	5	5	20	1	0	74	68	82	76	71	73
71	9	5	58	10	13	61	68	56	59	35	53
72	28	6	76	20	15	21	61	47	51	28	42
73	22	7	116	24	14	29	53	36	48	31	37
74	13	7	54	8	8	49	53	58	63	44	48

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† The time is given to the nearest minute.

‡ Scores are found by adding the percentile rank in repetitions to the percentile rank in perseverative errors and then again reducing to absolute percentiles by Rugg's table. The reason for this will appear later.

TABLE VI. Showing Correlations† and Partial Correlations of Each Factor‡ of the Rational Learning Test with the Binet-Simon Tests. The symbol for correlation has been omitted. The table should read $r_{12} = .27$, $r_{12.3} = .08$, etc.

12	.27	13	.31	14	.25	15	.23	16	.27
12·3	.08	13·2	.14	14·2	.05	15·2	.04	16·2	.15
12·4	.14	13·4	.17	14·3	.02	15·3	.02	16·3	.18
12·5	.16	13·5	.20	14·5	.11	15·4	—.02	16·4	.17
12·6	.10	13·6	.18	14·6	.03	15·6	.05	16·5	.19
12·34	.09	13·24	.14	14·23	—.02	15·23	—.02	16·23	.16
12·35	.08	13·25	.14	14·25	.04	14·24	—.01	16·24	.14
12·36	—.02	13·26	.15	14·26	—.03	15·26	.01	16·25	.14
12·45	.14	13·45	.17	14·35	.00	15·34	.00	16·34	.22
12·46	.10	13·46	.22	14·36	—.14	15·36	—.07	16·35	.18
12·56	.09	13·56	.19	14·56	—.02	15·46	.04	16·45	.17
12·345	.09	13·245	.14	14·235	—.01	15·234	.00	16·234	.20
12·346	.01	13·246	.20	14·236	—.14	15·236	—.07	16·235	.16
12·356	.00	13·256	.16	14·256	—.03	15·246	.04	16·245	.14
12·456	.10	13·456	.24	14·356	—.15	15·346	.08	16·345	.23
12·3456	.01	13·2456	.21	14·2356	—.14	15·2346	.08	16·2345	.21

† All correlations are worked by the product-moment method.

‡ For the sake of brevity the factors are designated by numbers as follows:

1. Binet-Simon Tests
2. Time
3. Repetitions
4. Unclassified Errors
5. Logical Errors
6. Perseverative Errors

TABLE VII. Showing Correlations and Partial Correlations of the Factors in the Rational Learning Test.

23	.72	24	.78	25	.72	26	.69	34	.78
23·4	.28	24·3	.50	25·3	.43	26·3	.55	34·2	.50
23·5	.43	24·5	.46	25·4	—.07	26·4	.26	34·5	.48
23·6	.60	24·6	.55	25·6	.26	26·5	.43	34·6	.72
23·45	.27	24·35	.30	25·34	—.04	26·34	.34	34·25	.34
23·46	.37	24·36	.22	25·36	.24	26·35	.44	34·26	.57
23·56	.44	24·56	.28	25·46	.00	26·45	.23	34·56	.55
23·456	.37	24·356	.03	25·346	.10	26·345	.34	34·256	.50
35	.71	36	.49	45	.94	46	.75	56	.64
35·2	.40	36·2	.00	45·2	.87	46·2	.47	56·2	.29
35·4	—.12	36·4	—.23	45·3	.88	46·3	.67	56·3	.45
35·6	.59	36·5	.07	45·6	.91	46·5	.59	56·4	—.30
35·24	—.10	36·24	—.32	45·23	.84	46·23	.55	56·23	.30
35·26	.41	36·25	—.14	45·26	.88	46·25	.47	56·24	—.28
35·46	—.24	36·45	—.30	45·36	.87	46·35	.64	56·34	—.33
35·246	—.22	36·245	—.36	45·236	.85	46·235	.58	56·234	—.34

If we consider the size of the probable error,[20] it seems safe to infer from the data in Table VI that repetitions and perseverative errors have elements in common with the criterion that are not common to the other factors or to each other. This conclusion is based on the correlations, $r_{13\cdot2456}$ and $r_{16\cdot2345}$, which are .21 in each case. This is three times the probable error and may be regarded as significant. Then if it is desired to score the Rational Learning Test so as to have it correlate highest with the Binet-Simon tests, these two factors must be included. It is evident that time, unclassified errors, and logical errors, have nothing in common with the criterion that is not included in the other four factors, if we hold that a correlation less than three times the probable error is not significant. It must also be kept in mind in this case that linearity is assumed. To be more specific, the expression, $r_{12\cdot3456}=.01$, means that everything common to 1 and 2 is contained in 3, 4, 5 and 6. Then factor 2, time, may be discarded if the remaining four are used. Further, since $r_{15\cdot346}=.08$, factor 5, logical errors, may be discarded. In like manner, since $r_{14\cdot36}=-.14$, it is fairly safe to discard factor 4, unclassified errors. It is true that a correlation of -.14 may be slightly significant. It may mean that, if the elements in repetitions and perseverative errors are removed, the more intelligent the subject the more errors he will make. Let the question be pushed further by the use of multiple correlation. By the use of formula (1), it is found that

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[20] The probable error for 74 cases is .075 for zero correlation and .063 for a correlation of .40. The probable errors are not given in each instance, since they are available in tables.

$$R_1(_{23456}) = .33$$

$$\text{But } R_1(_{36}) = .32$$

The difference between the correlation with the criterion when all five factors are used and when repetitions and perseverative errors only are used is small enough to be entirely neglected. This is further evidence that factors 3 and 6 are sufficient to use in the final scores. The correlation would be lowered, if anything were lost by discarding the others.

The next step is to find the proper combination of these two factors to give the best correlation. That is, must they be combined equally or in some other proportion? To determine this, formula (2) will be used. Repetitions will be designated as the major factor and perseverative errors as the minor factor. The fundamental constants for determining C are:

$$r_{IM} = .31$$
$$r_{Im} = .27$$
$$r_{Mm} = .49$$
$$\sigma_{M} = 16.35$$
$$\sigma_{m} = 15.56$$

When these values are substituted in formula (2), the result is 1.05, or for all practical purposes 1. This means that the two combined equally will give the best correlation. To determine what the correlation will be when the two factors are combined equally, formula (3) will be used, in which the letters have the same meaning as in formula (2). The correlation is found to be .33. The actual correlation when the scores in repetitions and perseverative errors are combined equally is .324.

The final scores are found by adding the percentile rank in repetitions to the percentile rank in perseverative errors and then again using Rugg's table for reducing to absolute percentiles as was done with the raw scores.

Multiple correlation indicated that a correlation of .32 could be obtained by combining repetitions and perseverative errors. Formula (2) indicated that the best combination is that in which they are combined equally. Formula (3) indicated that a correlation of .33 should be obtained when they are combined equally. When the actual combination is made and the correlation is worked out, the result is .324. The difference between these two numbers is small enough to be accounted for by the way fractions are carried out, and by using 1 instead of 1.05 as a ratio for combining.

(2) Analysis of Data.

There is a "present but low"[21] positive correlation in this test between the criterion and each of the factors. In other words, there is slight evidence that ability in the criterion and ability in each factor of the test accompany each other. Subjects above the average in the former will be above the average in each of the latter. Since the variability[22] is made the same in each kind of data by reducing to absolute percentiles, a change in one test or factor will be accompanied by a like change in the other test or factor, and equal to the correlation of the two tests or factors. Thus, time and the criterion have a correlation of .27. Therefore, every unit-change in one will be accompanied by a like change of .27 of a unit in the other. In like manner, each of the other factors may be compared with the criterion by reference to the correlations in Table VI. When the standard deviations are equal, the regression line for the columns takes the form $y = rx$ and that for the rows takes the form $x = ry$.

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[21] Correlations below .20 will be considered negligible; from .20 to .40, present but low; from .40 to .60, marked; above .60, high. See Rugg, H. O., *Statistical Methods Applied to Education,* 1917, 256.

Each factor in this test has something common to the criterion. Repetitions have most and unclassified errors least. There is, moreover, a great overlapping of common elements. Thus repetitions contain all that is common to time and the criterion, all that is common to unclassified errors and the criterion, and all that is common to logical errors and the criterion. Time has all that is in logical or unclassified errors with respect to the criterion. Unclassified and logical errors have practically the same elements as far as the criterion is concerned. Repetitions and perseverative errors have something, however, not found in any one of the other factors or in any combination of them. These two contain everything in all the factors needed to get the highest correlation with the criterion.

We shall use Blakeman's criterion[23] for linearity. When the proper values substituted in the formula give a result greater than 2.5, non-linearity will be said to exist and a table will be constructed showing the lines of the means of the rows and the means of the columns. If the result is less than 2.5, the correlation is for all practical purposes linear and no table of regression lines will be constructed.

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[22] The standard deviations for the Binet-Simon Tests, time, repetitions, unclassified errors, logical errors and perseverative errors are respectively 16.62, 16.47, 16.36, 16.68, 16.56, and 15.56.

[23] For formula, see Rugg, *Statistical Methods Applied to Education,* 1917, 283.

The correlation-ratios for each of the factors with the criterion are as follows:

12 = .46 and .52
13 = .41 and .47
14 = .47 and .52
15 = .44 and .49
16 = .37 and .40

These values substituted in the Blakeman formula give results as follows:

Tests 1 and 2,	2.37 and 2.83
Tests 1 and 3,	1.71 and 2.25
Tests 1 and 4,	2.54 and 2.90
Tests 1 and 5,	2.39 and 2. 76
Tests 1 and 6,	1.61 and 1.88

According to Blakeman's criterion, the correlations of repetitions and perseverative errors with The Binet-Simon tests are linear, but the correlations of time, unclassified, and logical errors with The Binet-Simon tests are non-linear. The regression lines for the last three correlations are now ready to be constructed.

The regression lines showing the correspondence between scores in time and the criterion are shown in Table VIII. Each asterisk indicates the position of one person as determined by both tests. The circles through which the broken line passes represent the means[24] of the columns and those through which the whole line passes represent the means of the rows. This table shows that the two sets of relationships are in very close agreement. That is, the regression of the x-values on y is very nearly the same as the y-values on x. The x-values show a tendency to increase constantly with an increase in y-values from the fortieth percentile up. Below this point there is little relation between x and y-values. The y-values have a tendency to increase constantly

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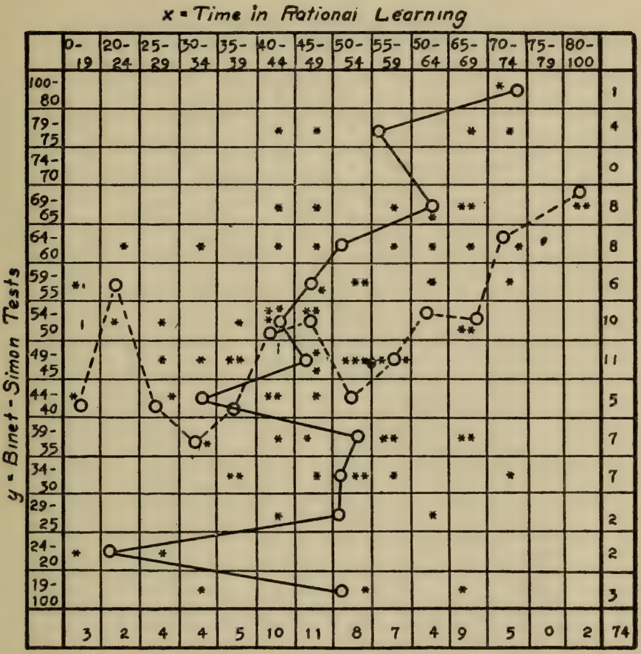
[24] The means for the columns or rows are found by adding the exact percentile ranks in each row or column and dividing by the number of cases.

TABLE VIII. Showing the Distribution of Subjects on the Basis of Time in Rational Learning and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



with an increase in x-values from the fiftieth percentile up. Below this point there is little relation between y and x-values.[25]

The relation between unclassified errors and the criterion is shown in Table IX. The agreement between the regression of the x-values on y and the y-values on x is not close. In neither case is the tendency for one value to increase with an increase in the other constant. The x-values increase with an increase in y-values from the fortieth percentile up to the sixtieth. The other regression line is almost horizontal from the thirtieth to the sixtieth percentile. An increase in Binet-Simon scores indicates nothing with respect to unclassified errors until the fortieth percentile is reached. An increase in Binet-Simon scores

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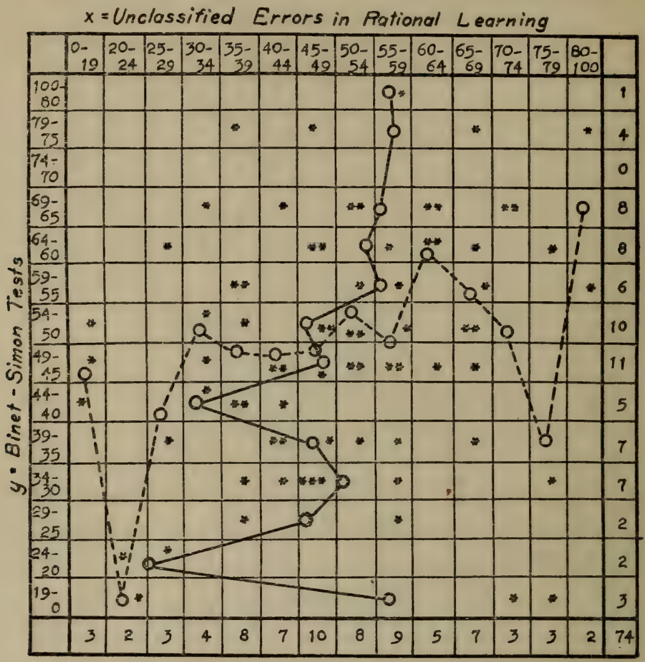
[25] Reasons for this lack of relation in the lower quartile will be suggested later in comparing the final scores with the criterion.

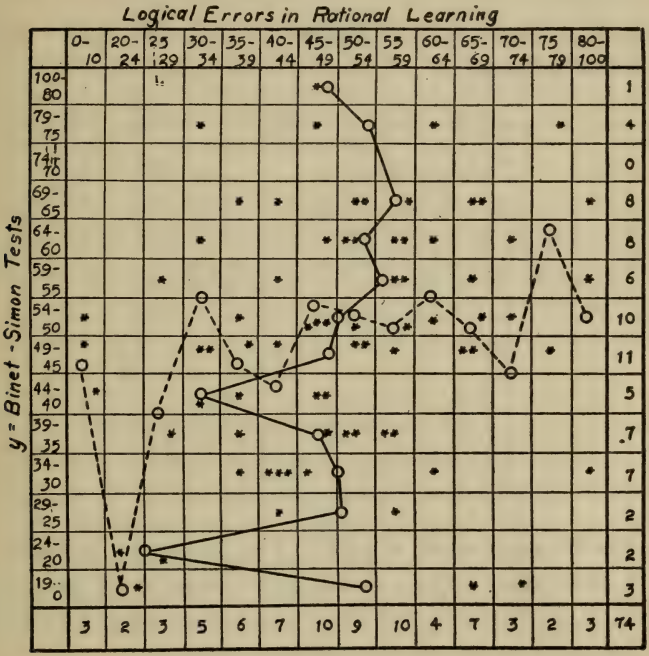
TABLE IX. Showing the Distribution of Subjects on the Basis of Unclassified Errors in Rational Learning and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



from the fortieth to the sixtieth percentile means a rather rapid increase in unclassified errors. Above the sixtieth percentile an increase in Binet-Simon scores means no change in unclassified errors. From the beginning to the end, an increase in unclassified errors means nothing with respect to intelligence as measured by the Binet-Simon Tests.

Table X shows the relation existing between logical errors and the criterion. The agreement between the two sets of values is not close. There is a fairly constant increase in y-values with an increase in x-values from the fortieth percentile up. A smoothed curve will show an increase from the very beginning. In the other regression line there is no tendency for the x-values to increase constantly. Up to the fortieth percentile an increase in Binet-Simon scores means no change in score in

TABLE X. Showing the Distribution of Subjects on the Basis of Logical Errors in Rational Learning and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



logical errors, but from here on to the sixty-fifth percentile, it means a constant increase. Above this point there are only five cases, and the curve has no significance.

The skewness of each distribution is almost zero, since the median and the mean almost coincide when the scores are reduced to percentiles. This assumes that skewness is measured in terms of the median, the mean, and the standard deviation. All medians and means are approximately 50, and all standard deviations are approximately 16.66.

VI. THE RATIONAL LEARNING TEST (*Modified*)

(1) Description of Test and Method of Scoring.

This test is very similar to Rational Learning. The apparatus consists of a board about twenty inches square, through which are put one hundred bolts arranged in ten rows with ten bolts in a row. The rows are lettered from A to J and the bolts in each are numbered 1 to 10. One bolt, and only one, in each row is connected in a circuit with an electric bell so that when this bolt is touched with a stylus the bell will ring. Figure I shows the apparatus.

Fig. I. Showing Apparatus for Rational Learning (Modified).

J	*	*	*	*	*	*	*	*	*	*
I	*	*	*	*	*	*	*	*	*	*
H	*	*	*	*	*	*	*	*	*	*
G	*	*	*	*	*	*	*	*	*	*
F	*	*	*	*	*	*	*	*	*	*
E	*	*	*	*	*	*	*	*	*	*
D	*	*	*	*	*	*	*	*	*	*
C	*	*	*	*	*	*	*	*	*	*
B	*	*	*	*	*	*	*	*	*	*
A	*	*	*	*	*	*	*	*	*	*
	1	2	3	4	5	6	7	8	9	10

Each asterisk represents a bolt. The bolts are actually numbered in each row just as indicated in row A in the diagram. The method of recording the data is exactly as in Rational Learning. The instructions to the subject follow:

"You have in the apparatus before you ten rows of bolts with ten bolts in each row. The rows are lettered from A to J and the bolts in each row are numbered from 1 to 10. One bolt in each row, and only one, is connected in such a way that the bell will ring when the circuit is made. That is, each letter is assigned a number in a random order from 1 to 10. This number is the one that will cause the bell to ring when the bolt is touched. No two letters have the same number.

Your problem is to begin with row A and find the bolt that will ring the bell. Then go on to row B and find the bolt. Continue until you have reached row J. Now go back to row A and repeat the process. Continue repeating the process until you go from A to J twice in succession without making any mistake. Then you are through.

You are to ask no questions after you start, but are to use all the mental powers at your command in order to complete the learning as soon as possible. You will be judged by (1) the total time you take, (2) the number of errors or wrong guesses you make (every bolt you touch being a guess), (3) the number of repetitions from A to J that you require for the learning. Re-read these instructions carefully, if necessary, to understand what you are to do. The meaning will be clearer as we go on with the experiment."

The subject stood facing the apparatus so that row A was toward him. The experimenter recorded every response just as was done in Rational Learning. When the test was finished the total time was recorded and the subject was asked to write as much as he could about the method he used in learning the problem.

The same three schedules of numbers were used in this test as in Rational Learning.[26] Those having schedule 1 in Rational Learning had schedule 2 in this one; those having schedule 3, had 1; and those having schedule 2, had 3. The same precaution was taken to prevent coaching as in Rational Learning. Each subject was asked not to tell any other member of the class anything that might assist in the learning. Results are given in Table XI.

Table XII shows that time has something in common with the criterion that is not common to the other factors. Perseverative errors seem to be least significant and may be dropped as far as the final scores are concerned. If we consider only the four factors and partial correlations of the third order, logical errors appear useless. In like manner, when the three remaining factors are considered alone, repetitions appear insignificant. If we push the analysis further, however, it is very evident that unclassified errors must be retained with time to make up the final score. We may make the analysis more logical by first considering $r_{16.2345} = .01$, which means that there is nothing common to 1 and 6 that is not contained in 2, 3, 4, and 5. Factor 6 may therefore be dropped. In like manner, since $r_{15\cdot234} = .03$

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[26] This test was given before Rational Learning.

TABLE XI. Showing the Number of Minutes, the Number of Repetitions, the Number of each Kind of Errors, and the Percentile Rank for Each Kind of Data in Rational Learning (Modified).

	Raw Score in					Percentile Rank in					
Subject	Time	Rep.	Uc.E.	L.E.	P.E.	Time	Rep.	Uc.E.	L.E.	P.E.	Score‡
1	3	4	47	19	0	82	75	75	69	76	79
2	7	10	138	72	3	68	51	43	41	58	56
3	7	4	42	18	3	68	75	82	71	58	77
4	10	7	55	17	3	57	65	69	73	58	67
5	2	3	45	16	0	87	82	77	76	76	85
6	11	7	70	24	3	53	65	63	63	58	59
7	9	10	102	16	13	61	51	53	76	38	58
8	18	12	182	67	21	37	42	35	43	28	35
9	27	10	124	60	8	18	51	46	46	46	32
10	15	9	130	61	5	43	56	44	46	53	43
11	13	13	115	58	9	46	39	49	48	45	48
12	10	9	69	23	0	57	56	64	65	76	61
13	10	12	164	90	5	57	42	40	33	53	49
14	11	10	142	58	11	53	51	42	48	41	48
15	10	7	67	37	2	57	65	65	58	63	64
16	4	4	59	23	0	79	75	68	65	76	73
17	17	18	261	94	16	40	16	21	32	34	29
18	10	7	66	27	15	57	65	65	61	36	61
19	7	10	145	66	4	68	51	42	43	55	55
20	16	16	176	72	22	41	27	35	41	25	38
21	12	8	128	79	6	49	59	45	38	51	46
22	7	7	95	55	1	68	65	54	49	68	64
23	17	15	167	83	2	40	33	38	35	63	40
24	6	3	48	22	3	74	82	73	67	58	73
25	15	12	114	38	11	43	42	50	57	41	46
26	6	6	73	22	2	74	70	61	67	63	70
27	9	9	92	48	6	61	56	55	54	51	59
28	9	7	116	67	5	61	65	49	43	53	55
29	11	10	124	50	8	53	51	46	52	46	49
30	7	7	43	26	2	68	65	79	62	63	73
31	28	12	165	83	24	14	42	39	35	21	23
32	19	12	123	55	10	33	42	47	49	43	40
33	14	16	207	141	15	45	27	32	18	36	39
34	12	10	118	65	3	49	51	48	44	58	49
35	23	14	217	122	47	24	37	30	21	0	25
36	29	14	236	110	14	0	37	25	26	37	0
37	10	9	106	49	2	57	56	52	53	63	54
38	18	14	314	152	30	37	37	0	14	14	14
39	5	3	25	4	0	77	82	87	87	76	85
40	13	10	127	58	10	46	51	45	48	43	45
41	11	10	74	26	4	53	51	51	62	55	53
42	9	12	73	23	0	61	42	61	65	76	64
43	12	11	110	54	13	49	46	51	50	38	51
44	23	15	292	153	24	24	33	14	0	21	18
45	19	6	78	34	6	33	70	59	59	51	45
46	11	7	85	49	3	53	65	58	53	58	56
47	18	16	231	109	11	37	27	28	28	41	33
48	15	8	71	29	8	43	59	62	60	46	53
49	12	15	109	44	18	49	33	51	54	31	51

TABLE XI (Continued)

Subject	Raw Score in					Percentile Rank in					
	Time	Rep.	Uc.E.	L.E.	P.E.	Time	Rep.	Uc.E.	L.E.	P.E.	Score‡
50	7	8	95	52	6	68	59	54	52	51	64
51	24	12	250	110	17	21	42	23	26	32	21
52	21	17	189	71	24	28	21	33	42	21	29
53	12	10	154	87	12	49	51	40	34	39	44
54	12	8	48	8	2	49	59	73	79	63	64
55	19	11	235	95	21	33	46	27	30	28	27
56	17	14	172	78	7	40	37	36	38	49	38
57	9	8	131	62	0	61	59	43	45	76	53
58	13	18	269	117	16	46	16	18	23	34	32
59	19	15	151	83	2	33	33	41	35	63	36
60	15	16	207	74	19	43	27	32	40	30	37
61	13	13	59	5	16	46	39	68	82	34	58
62	9	8	100	43	7	61	59	54	55	49	58
63	19	15	166	81	11	33	33	38	37	41	34
64	19	12	91	29	7	33	42	56	60	49	44
65	11	11	122	76	1	53	46	48	39	68	51
66	19	9	105	41	2	33	56	52	56	63	42
67	14	16	167	64	9	45	27	38	45	45	42
68	7	11	88	37	6	68	46	58	58	51	67
69	12	11	104	53	11	49	46	53	51	41	52
70	7	10	61	20	2	68	51	66	68	63	69
71	17	24	188	94	9	40	0	34	32	45	36
72	22	7	91	41	4	27	65	56	56	55	42
73	8	10	88	52	1	64	51	58	52	68	64
74	8	6	52	18	0	64	70	70	71	76	69

† Scores are found by adding the percentile rank in time to the percentile rank in unclassified errors and then again reducing to absolute percentiles by Rugg's table. The reason for this will appear later.

TABLE XII. Showing Correlations and Partial Correlations of Each Factor† of Rational Learning (Modified) with the Binet-Simon Tests.

12	.42	13	.31	14	.44	15	.42	16	.35
12·3	.31	13·2	.08	14·2	.24	15·2	.23	16·2	.11
12·4	.19	13·4	—.05	14·3	.33	15·3	.30	16·3	.21
12·5	.23	13·5	.04	14·5	.15	15.4	.04	16·4	.07
12·6	.27	13·6	.13	14·6	.29	15·6	.28	16·5	.12
12·34	.20	13·24	.08	14·23	.24	15·23	.21	16·23	.08
12.35	.23	13·25	—.04	14·25	.08	15·24	.04	16·24	.00
12·36	.24	13·26	.04	14·26	.20	15·26	.20	16·25	.04
12·45	.19	13·45	—.05	14·35	.15	15·34	.04	16·34	.07
12·46	.17	13·46	—.06	14·36	.27	15·36	.25	16·35	.12
12·56	.19	13·56	.00	14·56	.10	15·46	.05	16·45	.07
12·345	.20	13·245	—.08	14·235	.11	15·234	.03	16·234	.01
12·346	.19	13·246	—.09	14·236	.23	15·236	.20	16·235	.04
12·356	.19	13·256	—.05	14·256	.07	15·246	.04	16·245	.01
12·456	.17	13·456	—.05	14·356	.11	15·346	.04	16·345	.08
12·3456	.19	13·2456	—.08	14.2356	.10	15·2346	.03	16·2345	.01

†For the sake of brevity the factors are designated by numbers as follows:

1.	Binet-Simon Tests	4.	Unclassified Errors
2.	Time	5.	Logical Errors
3.	Repetitions	6.	Perseverative Errors

factor 5 may be discarded. Since $r_{13\cdot24} = .08$, factor 3 may be discarded. But since $r_{12\cdot4} = .19$, and $r_{14\cdot2} = .24$, it is evident that factors 2 and 4 must be retained.

This conclusion may be further verified by using multiple correlation. The following results are found:

$$R_1(_{23456}) = .479$$
$$R_1(_{24}) \quad = .473$$

It is seen from the above that very little is lost by excluding all the factors except time and unclassified errors. We shall use for our final scores, then, these two factors which appear to give everything that is necessary to get the highest correlation with the criterion.

Our next problem is to find the combination of time and unclassified errors that will give this best correlation. The same formulae will be used as were used in Rational Learning. Designating unclassified errors by M and time by m, we may use the following data for finding the best value of C and the resulting correlation:

$$r_{IM} = .44$$
$$r_{Im} = .42$$
$$r_{Mm} = .66$$
$$\sigma_{M} = 16.59$$
$$\sigma_{m} = 16.65$$

When these values are substituted in formula (2), the value of C is found to be .79. This means that the best combination of time and unclassified errors is to add .79 of the time to the unclassified errors. This gives a correlation of .47; but if 1 is used in the formula instead of .79, the correlation is still .47. For our final score in this test, we shall use time and unclassified errors combined equally. The exact method of getting them will be to add together the scores in time and unclassified errors and then reduce to absolute percentiles by the same method as was used in Rational Learning.

(2) Analysis of Data.

There is a "present but low" positive correlation between the criterion and repetitions and between the criterion and perseverative errors. The correlation of the criterion with each of the other factors is "marked." Subjects above the average in the former will tend to be above the average in each of the latter. Since the variability[27] is made the same in each kind of data by reducing to absolute percentiles, a unit-change in one test or factor will be accompanied by a like change in the other test or factor equal to the correlation of the two factors. Thus time and the criterion have a correlation of .42. Therefore every unit-change in one will be accompanied by .42 of a unit-change in the other. In like manner, each of the other factors may be compared with the criterion by reference to the correlations in Table XII.

Each factor in this test has much in common with the criterion. Unclassified errors have most and repetitions least. Table XII shows that time contains all that is common to repetitions and the criterion and nearly all that is common to perseverative errors and the criterion. Unclassified errors contain all that is common to the criterion and any one of the three factors, repetitions, logical errors and perseverative errors. Logical errors contain all that is common to repetitions and the criterion.

TABLE XIII. Showing Correlations and Partial Correlations of the Factors in the Rational Learning Test (Modified).

23	.60	24	.66	25	.61	26	.65	34	.77
23·4	.19	24·3	.39	25·3	.36	26·3	.45	34·2	.62
23·5	.33	24·5	.32	25·4	.01	26·4	.35	34·5	.53
23·6	.34	24·6	.38	25·6	.36	26·5	.45	34·6	.61
23·45	.20	24·35	.18	25·34	.05	26·34	.33	34·25	.47
23·46	.15	24·36	.23	25·36	.24	26.35	.38	34·26	.55
23·56	.21	24·56	.14	25·46	.07	26.45	.36	34·56	.45
23·456	.16	24·356	.06	25·346	.09	26·345	.34	34·256	.42
35	.67	36	.61	45	.92	46	.70	56	.60
35·2	.48	36·2	.36	45·2	.87	46·2	.48	56·2	.34
35·4	—.16	36·4	.16	45·3	.85	46·3	.45	56·3	.33
35·6	.48	36·5	.35	45·6	.87	46·5	.47	56·4	—.15
35·24	—.16	36·24	.10	45·23	.83	46·23	.34	56·23	.20
35·26	.41	36·25	.24	45·26	.85	46·25	.39	56·24	—.17
35·46	—.13	36·45	.14	45·36	.83	46·35	.35	56·34	—.13
35·246	—.14	36·245	.07	45·236	.82	46·235	.32	56·234	—.16

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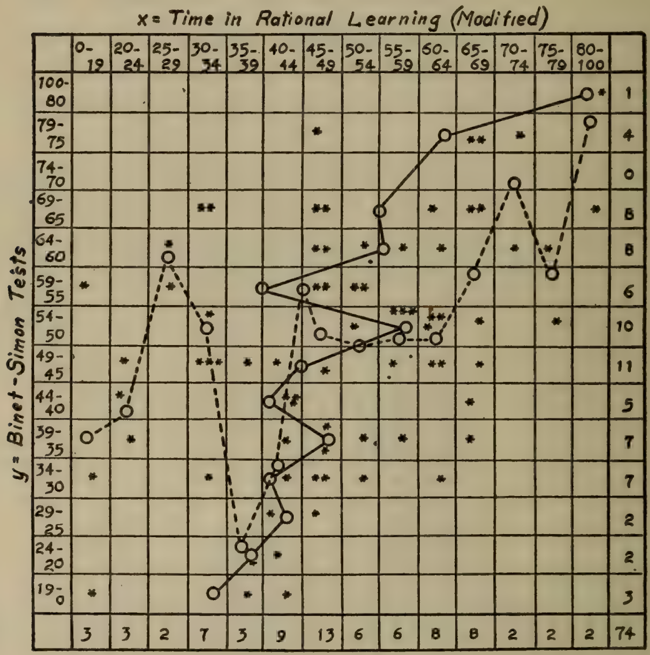
[27] The standard deviations for time, repetitions, unclassified errors, logical errors, and perseverative errors are 16.65, 16.48, 16.59, 16.68, and 16.35 respectively.

Table XIII shows that the factors have a "high" correlation with each other. Unclassified and logical errors have the highest. Since the correlation of these two factors is so high, neither of them can have very much that is not in the other.

Table XIV. Showing the Distribution of Subjects on the Basis of Time in Rational Learning (Modified) and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns, and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



The several correlation-ratios for each of the factors with the criterion are as follows:

12 = .56 and .66
13 = .47 and .59
14 = .53 and .61
15 = .58 and .60
16 = .49 and .49

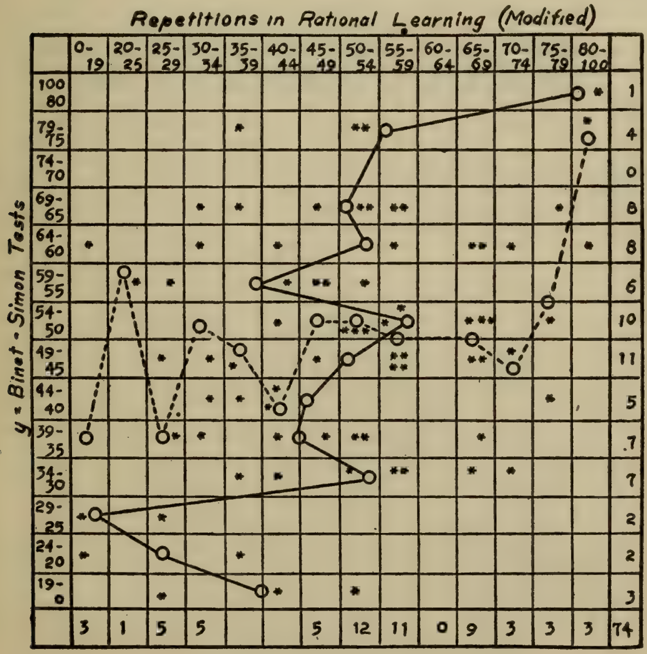
The Blakeman formula gives results as follows:

Tests 1 and 2,	2.36 and 3.24
Tests 1 and 3,	2.25 and 3.20
Tests 1 and 4,	1.87 and 2.69
Tests 1 and 5,	2.55 and 2.73
Tests 1 and 6,	2.19 and 2.19

All the correlations are non-linear except the last one, the criterion and perseverative errors.

Table XIV shows the correspondence between scores in time and the criterion. The Blakeman formula indicates that each of the regression lines is non-linear. The curve of the means of the rows shows very little change in x-values with an increase in y-values up to the fifty-fifth percentile, where the change is accelerated, probably, on account of the fact that the Binet-Simon

Table XV. Showing the Distribution of subjects on the Basis of Repetitions in Rational Learning (Modified) and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns, and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



tests do not actually test the brightest subjects. The curve of the means of the columns has four distinct parts. As the x-values increase, the y-values decrease rapidly from the twenty-fifth to the thirty-fifth percentile, increase rapidly from the thirty-fifth to the forty-fifth percentile, remain about the same from the forty-fifth to the sixty-fifth percentile, and increase rapidly from the sixty-fifth percentile.

Table XV shows the correspondence between the scores in repetitions and the criterion. The regression line of the means of the columns may be considered linear according to the Blakeman test. The regression line of the means of the rows, however, is non-linear. The non-linearity is caused by the four cases in the second and third rows from the botton and the one case in the top row. The removal of these five cases will reduce the

TABLE XVI. Showing the Distribution of Subjects on the Basis of Unclassified Errors in Rational Learning (Modified) and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.

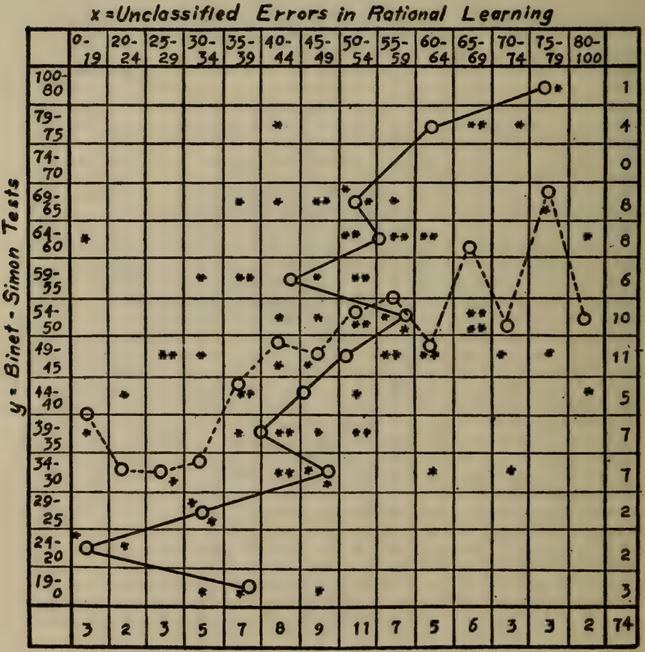
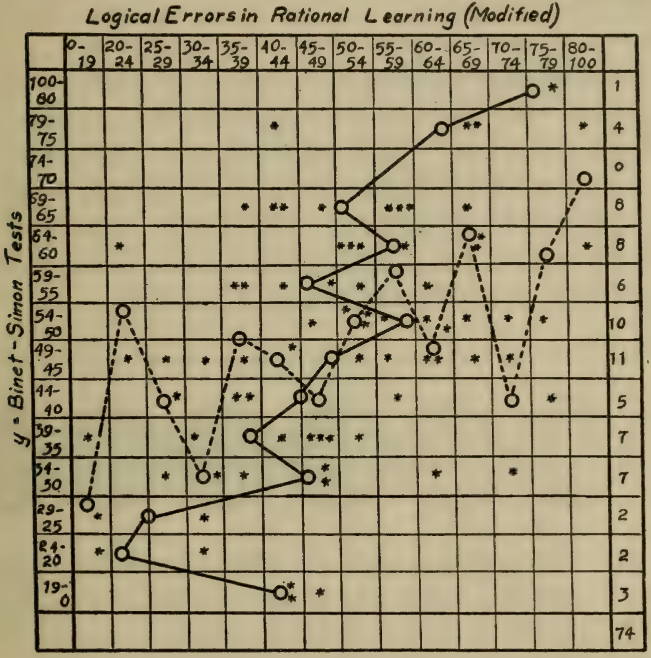


TABLE XVII. Showing the Distribution of Subjects on the Basis of Logical Errors in Rational Learning (Modified) and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



correlation-ratio from .59 to .34, provided the mean and standard deviation are not changed. Such a reduction in correlation-ratio will destroy the non-linearity.

Table XVI shows the correspondence between the scores in unclassified errors and the criterion. The regression line of the means of the columns is linear according to the test. The other regression line, however, is non-linear. The non-linearity can be eliminated by removing the two cases in the second row from the bottom. The same result can be obtained by assuming that these two cases fall on the median.

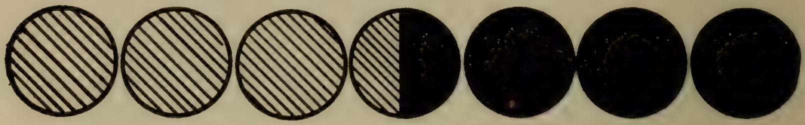
Table XVII shows the correspondence between the scores in logical errors and the criterion. Here both regression lines are slightly non-linear. The non-linearity, however, is due to a few cases and for that reason has no significance.

VII. CHECKER PUZZLE

(1) Description of Test and Method of Scoring.

This may be called a checker puzzle test because of its similarity to the game of checkers. As far as the writer knows it was first used as a psychological experiment by Dr. Strong in the Jesup Psychological Laboratory of George Peabody College for Teachers. He also gives a suggestion for its use in the Psychological Bulletin.[28] The instructions to the subject and the method of scoring are different in many respects from those used in the Jesup Psychological Laboratory. They were devised by the writer, but, of course, reflect to a considerable degree those with which he was already acquainted.

FIG. II. Showing Apparatus Used in the Checker Puzzle Test.



The subject is given a card on which are seven circles as shown in Figure II. He is also given three red and three black checkers. The instructions to the subject are as follows:

"You are here given a row of seven circles. The three at the left are red, the three at the right are black, and the middle one is black on the right half and red on the left half. You are also given three red and three black checkers. You are to place the three red checkers on the three black circles and the three black checkers on the three red circles.

"Your problem is to get the three red checkers on the three red circles and the three black checkers on the three black circles. You must move but one checker at a time, jump only one at a time, and never move backwards. When you are blocked so that you cannot move farther, set the checkers back to the starting point and begin anew. When you can go through the problem three times in succession without any errors, we will consider it learned. Keep in mind that your results are being judged (1) by the time spent, (2) by the number of attempts (each time you begin counting an attempt, whether you are successful or not), (3) by the number of successful solutions required for the learning."

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[28] Strong, E. K., Jr., The Learning Process, "*Psychol. Bull.,* 1918, XV, 328 ff.

The subject sat at one side of the table and the experimenter at the other. The latter kept an accurate account of the time, the number of attempts, and the number of successful solutions.

The results are found in Table XVIII.

TABLE XVIII. Showing the Number of Minutes, the Number of Attempts, the Number of Solutions, and the Percentile Rank for Each Kind of Data in the Checker Puzzle Test.

	Score in			Percentile Rank in				Score in			Percentile Rank in		
Subject	T	A	S	T	A	S	Subject	T	A	S	T	A	S
1	9	11	4	74	15	78	38	19	30	12	53	39	25
2	16	15	6	58	63	59	39	8	7	5	81	86	69
3	17	23	9	56	51	40	40	9	8	6	74	82	59
4	26	14	6	41	65	59	41	14	16	6	61	61	59
5	12	20	8	67	54	46	42	13	17	6	64	59	59
6	22	18	6	49	58	59	43	18	16	10	55	61	35
7	26	14	3	41	65	86	44	19	30	6	53	39	59
8	31	28	9	35	43	40	45	13	12	8	64	70	46
9	16	18	8	58	58	46	46	25	27	8	45	44	46
10	29	24	7	38	48	52	47	30	25	7	37	46	52
11	29	29	6	38	42	59	48	58	57	9	14	18	40
12	11	14	5	69	65	69	49	24	30	6	45	39	59
13	19	32	6	53	36	59	50	52	49	11	19	25	31
14	10	12	6	70	70	59	51	52	49	11	19	25	31
15	21	25	15	51	46	52	52	12	19	7	67	56	52
16	29	23	6	38	51	59	53	21	30	8	51	39	46
17	23	24	9	47	48	40	54	24	25	5	45	46	69
18	20	10	8	52	77	46	55	26	37	11	41	34	31
19	19	23	7	53	51	52	56	41	52	14	23	21	0
20	35	45	9	33	28	40	57	8	13	5	81	67	69
21	13	9	6	64	79	59	58	14	16	5	61	61	69
22	22	30	12	49	39	25	59	25	33	13	43	35	16
23	9	23	6	74	51	59	60	35	41	10	33	30	35
24	35	23	8	33	51	46	61	25	21	8	43	53	46
25	36	46	13	29	27	16	62	16	19	5	58	56	69
26	6	12	8	86	70	46	63	37	29	8	25	42	46
27	12	19	4	67	56	78	64	19	16	4	53	61	78
28	17	28	8	56	43	46	65	15	39	8	60	32	46
29	30	23	6	37	51	59	66	9	21	5	69	53	69
30	13	12	8	64	70	46	67	28	12	10	40	70	35
31	36	31	10	29	37	35	68	12	18	8	67	58	46
32	24	25	6	45	46	59	69	36	62	11	29	14	31
33	23	20	9	47	54	40	70	23	32	9	47	36	40
34	36	38	7	29	33	52	71	62	80	12	0	0	25
35	21	23	9	51	51	40	72	15	13	4	60	67	78
36	23	27	10	47	44	35	73	16	17	7	58	59	52
37	21	40	12	51	31	25	74	33	23	6	35	51	59

TABLE XIX. Showing Correlations and Partial Correlations of Each Factor* of the Checker Puzzle with the Binet-Simon Test and with Each Other.

12	.26	13	.18	14	.20
12·3	.18	13·2	.03	14·3	.06
12·4	.19	13·4	.05	14·2	.08
12·34	.18	13·24	—.03	14·23	.06
23	.62	24	.51	34	.76
23·4	.41	24·3	.08	34·2	.65

*For the sake of brevity the factors will be designated as follows:

1. Binet-Simon Tests
2. Solutions
3. Attempts
4. Time.

Since $r_{14\cdot 23} = .06$, factor 4 has nothing in common with the criterion that is not contained in factors 2 and 3. In like manner, since $r_{13\cdot 2} = .03$, factor 3 has nothing in common with the criterion that is not contained in factor 2. Nothing will be lost, therefore, as far as the criterion is concerned, by discarding time and attempts from the final score. For the present purpose, then, we shall use only the number of solutions as the final score. The formula for multiple correlation shows that it is not possible by combining the factors to get a higher correlation with the criterion than .27. The range of solutions is so small that the scores are bunched considerably. This probably affects the correlation somewhat, but there is no way to remedy it. It cannot be raised by using the other factors in any way. The present method has for its purpose to get the highest correlation with the criterion.

(2) Analysis of Data.

There is a "present but low" positive correlation between the criterion and time and between the criterion and solutions. The correlation is negligible, however, between the criterion and the number of attempts. Since the variability[29] is the same in each kind of data, each factor may be directly compared with the criterion by reference to Table XIX. Thus, for every unit-change in solutions there will be a like change of .26 of a unit in the criterion, and vice versa.

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[29] The standard deviations for time, attempts, and solutions are 16.57, 16.54, and 16.1 respectively.

The factors, solutions and time, have something in common with the criterion. Solutions have most and contain elements not contained in either of the other factors. Time contains nothing with respect to the criterion that is not contained also in solutions. Each of the factors is composed largely of elements not found in the criterion. Solutions and attempts have a high correlation with each other as have time and attempts. The correlation of solutions and time is marked.

The correlation-ratios for each of the factors with the criterion are as follows:

12 = .49 and .54
13 = .30 and .42
14 = .40 and .44

These values substituted in the Blakeman formula give results as follows:

Tests 1 and 2, 2.71 and 3.05
Tests 1 and 3, 1.52 and 2.42
Tests 1 and 4, 2.21 and 2.50

According to our test, the correlation of the criterion and solutions is non-linear. The other two correlations are linear. A table will be constructed to show the regression lines in the correlation of solutions and the Binet-Simon tests. This will be postponed, however, until the final scores are analyzed.

VIII. The Tait Labyrinth Puzzle

(1) Description of Test and Method of Scoring.

In this test the subject was given a figure of the Tait Labyrinth Puzzle and a copy of the instructions. Freeman[30] has given suggestions as to its use. Lindley[31] also used it in his "Study of Puzzles." The figure and instructions are here given.

"You have before you a figure that can be drawn without lifting the pencil from the paper and without retracing. Your problem is to draw the figure without lifting the pencil from the paper and without retracing. As soon as you are ready you may begin on this blank sheet of paper. You may keep the figure before you and refer to it during the drawing if you wish. No attention will be given to the technical excellence of the drawing. If you fail in the first attempt, take another sheet of paper and try it again. Continue until you have made the figure three times in succession without any errors. You are to be judged by the number of trials required for the learning and by the number of minutes used."

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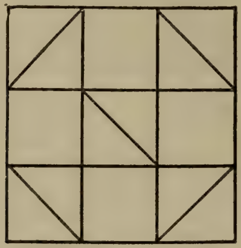
[30] Freeman, F. N., *Experimental Education*, 1916, 36 ff.
[31] Lindley, E. H., Study of Puzzles, *Amer. J. of Psychol.*, *8*, 430 ff.

FIG. III. Showing the Tait Labyrinth Puzzle.



When the subject started, the time was noted and then noted again when the problem was complete. This time included that used in reading the directions as well as that used in solving the problem. It was thought necessary to include the time used in reading the directions, since so many will trace the pencil in the air over the figure before trying to draw it on paper.

If we designate the number of trials by 2 and the number of minutes by 3, the correlations are as given in Table XXI.

The best possible combination of time and trials gives a correlation of .30 with the Binet-Simon tests. Since $r_{13\cdot2}$ gives a correlation of .01, there is nothing common to time and the criterion that is not contained in trials. Therefore the final scores for comparison with the criterion will consist of the percentile ranks in number of trials.

(2) Analysis of Data.

There is a "present but low" positive correlation between the criterion and number of trials. The correlation of the criterion with the number of minutes, however, is "negligible." Since the

TABLE XX. Showing the Number of Trials, the Number of minutes, and the Percentile Rank in Each Kind of Data in Tait Labyrinth Puzzle.

Subject	Score in		Per. Rank in		Subject	Score in		Per. Rank in	
	Trials	Time	Trials	Time		Trials	Time	Trials	Time
1	11	6	43	66	38	34	52	14	14
2	19	24	31	33	39	5	11	67	50
3	6	8	59	59	40	17	10	35	54
4	5	10	67	54	41	6	11	59	50
5	6	6	59	66	42	5	7	67	63
6	12	13	42	46	43	6	10	59	54
7	14	14	37	45	44	25	31	23	21
8	22	21	27	38	45	7	12	57	48
9	5	6	67	66	46	10	11	46	50
10	25	24	23	33	47	9	7	50	63
11	5	22	67	37	48	17	29	35	25
12	9	10	50	54	49	9	18	50	21
13	3	13	82	46	50	14	26	37	28
14	7	7	57	63	51	5	9	67	57
15	25	24	23	33	52	13	23	40	35
16	13	25	40	30	53	10	8	46	59
17	17	30	35	23	54	12	17	42	42
18	11	4	43	72	55	18	13	33	46
19	6	8	59	59	56	18	67	33	0
20	10	11	46	50	57	25	17	23	42
21	22	19	28	40	58	10	10	46	54
22	9	4	50	72	59	13	15	40	43
23	11	19	43	40	60	8	7	53	63
24	8	7	53	63	61	5	11	67	50
25	8	10	53	54	62	4	4	76	72
26	20	26	31	28	63	5	15	67	43
27	5	8	67	59	64	7	3	57	78
28	8	2	53	84	65	8	23	53	35
29	3	5	82	68	66	8	33	53	18
30	9	4	50	72	67	10	12	46	48
31	13	21	40	38	68	5	3	67	78
32	3	8	82	59	69	10	11	46	50
33	14	23	37	35	70	6	2	59	84
34	9	24	50	33	71	38	14	0	45
35	5	10	67	54	72	4	10	76	54
36	6	9	59	57	73	5	4	67	72
37	13	8	40	59	74	8	19	53	40

TABLE XXI. Showing the Correlations and Partial Correlations of Each Factor in the Tait Labyrinth Puzzle with the Binet-Simon Tests.

12	.30
12·3	.26
13	.17
13·2	.01
23	.55

variability[32] is the same in each kind of data, each factor may be compared directly with the criterion by reference to Table XXI. Thus, for every unit change in number of trials there will be a like change of .30 of a unit in the criterion and vice versa.

It has already been noted that time contains nothing with respect to the criterion that is not contained in number of repetitions. Trials and minutes show a "marked" correlation with each other.

The correlation-ratios of the factors of this test with the criterion are:

12 = .46 and .54
13 = .33 and .44

When these values are substituted in Blakeman's formula, results as follows are obtained:

For tests 1 and 2, 2.22 and 2.86
For tests 1 and 3, 1.80 and 2.59

One of the regression lines in each correlation is linear and the other non-linear. Table XXII shows the correspondence between time and the criterion. The regression line of the means of the columns is relatively linear and shows an increase in y-values with an increase in x-values from the lowest to the highest percentile. The regression line of the means of the rows is relatively non-linear. It shows a rapid increase in x-values with an increase in y-values from the twentieth to the fortieth percentile. The x-values change very little until the sixtieth percentile is reached and then the increase is again rapid.

Since the percentile ranks in trials are used as the final scores, the table showing the correspondence between this factor and the criterion will be postponed until the next section.

IX. INTERCORRELATIONS

(1) Tests Analyzed in the Light of the Criterion.

We shall first analyze the scores in the light of the criterion. The final scores are obtained in Rational Learning by combining repetitions and perseverative errors equally, in Rational Learn-

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[32] The standard deviations for trials and time are 16.33 and 16.58 respectively.

TABLE XXII. Showing the Distribution of Subjects on the Basis of Time in the Tait Labyrinth Puzzle and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.

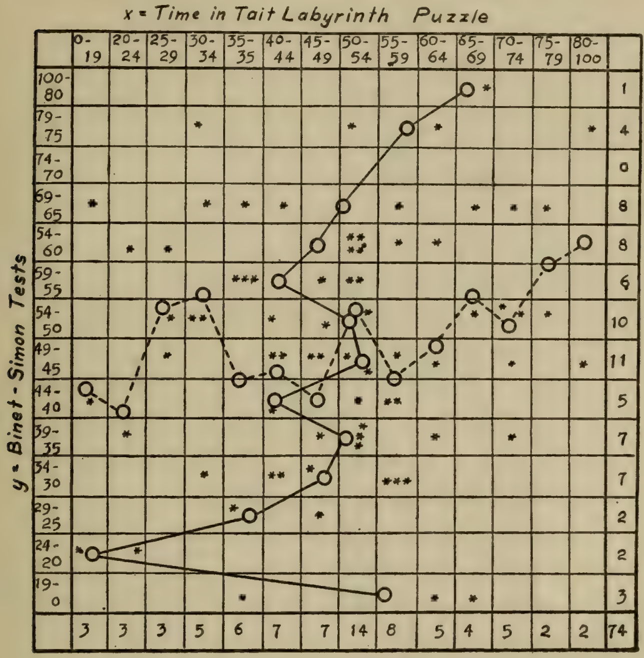


TABLE XXIII. Showing the Correlations and Partial Correlations for the Final Scores* with the Binet-Simon Tests.*

12	.33	13	.47	14	.26	15	.30
12·3	.20	13·2	.40	14·2	.17	15·2	.19
12·4	.27	13·4	.43	14·3	.13	15·3	.25
12·5	.24	13·5	.45	14·5	.19	15·4	.25
12·34	.18	13·24	.38	14·23	.09	15·23	.19
12·35	.11	13·25	.40	14·25	.14	15·24	.17
12·45	.21	13·45	.42	14·35	.07	15·34	.22
12·345	.11	13·245	.38	14·235	.06	15·234	.18

* The numbers have the following meaning:

1. Binet-Simon Tests.
2. Rational Learning.
3. Rational Learning (Modified).
4. Checker Puzzle.
5. Tait Labyrinth Puzzle.

ing (Modified) by combining minutes and unclassified errors equally, in the Checker Puzzle by taking the solutions, and in the Tait Labyrinth Puzzle by taking the number of trials.

(a) Rational Learning. There is a "present but low" positive correlation between the final scores in Rational Learning and the criterion. The correlation is partly due to elements found also in Rational Learning (Modified), found to a less extent in the Tait Labyrinth Puzzle, and to a still less extent in the Checker Puzzle. The correlation is significant when the common elements in any one of the other three tests are removed, but when the common elements found also in all the other three tests are removed, the correlation is no longer significant. In other words, everything common to the criterion and Rational Learning is found in the other three tests.

The correlation ratios for The Binet-Simon tests and Rational Learning are .47 and .51. These values substituted in Blakeman's formula give 2.13 and 2.47, which indicate that for all practical purposes the correlation is linear.

Rational Learning seems to measure some mental functions not detected by the Binet-Simon tests. The first that may be mentioned is that of being able to attack and solve a problem without getting confused. In support of this statement some special cases are cited. Subject 6 scores "high" in each factor of Rational Learning, but "low" in the criterion. She grasped the situation quickly and completed the learning with only 23 errors. Subject 9 scores "high" in unclassified, logical, and perseverative errors, but "low" in the criterion. She made only 17 errors in the first repetition and finished with a total of 21. We have altogether nine subjects who score "low" in the criterion and "high" in one or more factors in Rational Learning. An examination of the individual records shows that in every case the learning was completed without confusion or distraction.

A second mental function that Rational Learning seems to test better than does the criterion is the ability to give attention longer and to more elements than is usually required in the latter tests. Subject 26 illustrates this point fairly well. She scores "high" in the criterion and "low" in repetitions and perseverative errors. She has 88 unclassified errors altogether and 70 of these were made in the first two repetitions. The other 18 are distributed from the third to the eighth inclusive. The record indicates that the learning was almost complete in the third repetition, in which only two errors were made, yet five more repetitions were required. Subjects 34 and 42 have records similar to that of 26; that is, they have a few errors distributed over several repetitions, a condition which indicates a lack of attention.

A third mental function or process measured better by Rational Learning than by the criterion is the kind of attack. Some subjects read the instructions and make sure that every point is understood before beginning. Others read them in a careless way and jump into the problem without knowing just what is to be done. Subject 2 illustrates the later method. She made 77 unclassified and 44 logical errors in the first two repetitions. Subject 72 made 5 of her 8 perseverative errors in the first repetition. This indicates that the instructions were not fully understood.

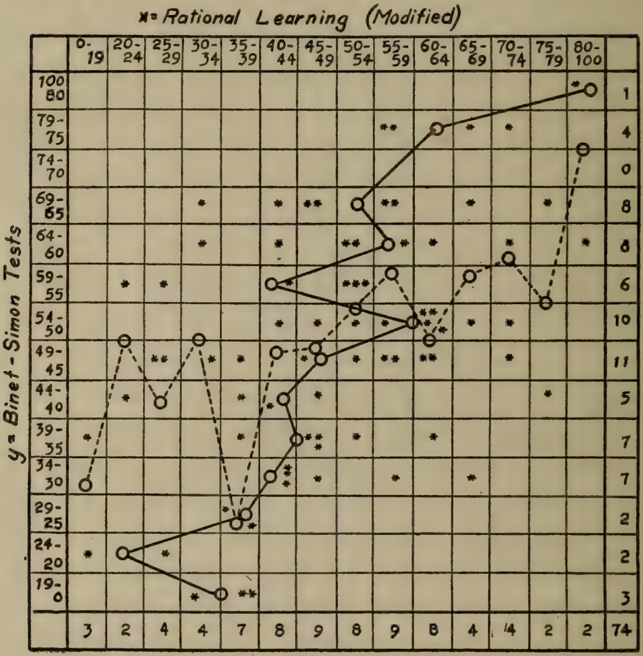
The fourth and last mental function that seems to be especially well brought out by Rational Learning is the speed of the subject. This may be illustrated by subject 72. She scores "high" in the criterion and "low" in time and perseverative errors. She is a mature woman who goes at everything slowly and deliberately. Subject 40 also is a good example. She worked very slowly and deliberately, thus making a "high" score in repetitions.

(b) Rational Learning (Modified). The correlation of Rational Learning (Modified) and the criterion is "marked." The elements common to the two tests are found to a slight extent in each of the other three tests. The correlation of the third order shows that Rational Learning (Modified) has elements common to the criterion not found in any one of the other three tests or in all of them combined. This means that Rational Learning (Modified) contains elements not found in the other tests.

The correlation-ratios for Rational Learning (Modified) and the criterion are .60 and .63. These values substituted in the

Blakeman formula give 2.37 and 2.69, indicating that one regression line is linear and the other non-linear. Table XXIV shows the actual regression lines. The line joining the means of the rows is relatively linear and the line joining the means of the columns is relatively non-linear. The non-linearity would be eliminated if the average of the seven cases in the fifth column from the left were 50 instead of 26. The number of cases in each row and column is too small for the non-linearity to have any significance when the curve does not take any well defined shape.

TABLE XXIV. Showing the Distribution of Subjects on the Basis of Rational learning (Modified) and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



In Rational Learning, repetitions and perseverative errors are the significant factors. In Rational Learning (Modified), however, the significant factors are time and unclassified errors. The cause of this difference is interesting and can be stated only on a priori grounds. In the former, repetitions are more significant than time and contain everything in time with respect to the criterion. The reverse, however, is the case with Rational Learning (Modified). Time includes all that is in repetitions. The writer is of the opinion that the experimenter, in calling out the numbers, controls the speed of the subject to some extent. He enters into the situation in a different way from what he does when he stands back and records the responses. The writer has found that when a subject is naming words, the speed is checked if the words are recorded in plain view of the subject.

The next problem is to try to answer why perseverative errors in Rational Learning and unclassified errors in Rational Learning (Modified) are the significant factor. This also can be stated only on a priori grounds. It is probable that in the latter experiment space perception makes it easier to avoid perseverative errors than in the former. The tendency seems to be to go from one end of a row to the other and to skip about here and there less than in Rational Learning.

An analysis of individual cases indicates that Rational Learning (Modified) tests the same factors as Rational Learning. First, it tests the subject's ability to work for a period of time without confusion or distraction better than the criterion does. In support of this some special cases are cited. Subject 6 scores "low" in the criterion and "high" in time, repetitions, and unclassified errors. The data shows that she was able to concentrate her attention and learn the problem without confusion. Subject 22 scores "low" in the criterion and "high" in time, repetitions, and perseverative errors. She learned this test quickly and was able to avoid confusion and distraction.

Second, Rational Learning (Modified) tests a subject's ability to give attention longer and to a more complex situation than that usually required by the criterion. Subject 11 illustrates this point. She scores "high" in the criterion and "low" in repetitions. In five of the repetitions only one error was made for each. Certainly close attention would have cut down the number. Subject 49 has a "high" score in the criterion and a "low" one in repetitions and perseverative errors. The "low" score in repetitions of this subject also is caused by a lack of attention, as was that of subject 11. This conclusion is based on the fact that she made from zero to three errors in each repetition from the sixth to the thirteenth. Subject 61 scored "high" in the criterion and "low" in repetitions and perseverative errors. She made only one error in the third repetition, yet she required thirteen repetitions to complete the learning. The greatest number of errors made in any repetition after the second is three. This too probably shows a lack of attention to the correct numbers.

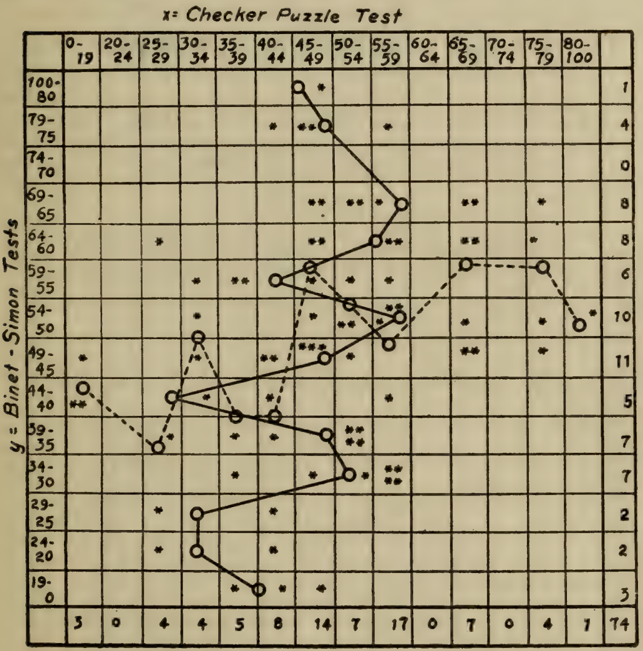
In the third place, Rational Learning (Modified) is better for detecting the kind of attack than is the criterion. It is possible to determine whether the subject approaches the problem with that deliberate method which indicates that he is sure of what is to be done, or approaches it in that method characteristic of the person who gets an inkling of what is to be done and then begins in a kind of hit-and-miss sort of way.

The fourth mental function that is revealed in this test is the speed of the subject. Here we have reference to the procedure after the instructions have been read and the subject has begun. This is illustrated by subject 66. He scores "high" in the criterion and "low" in time. The 'low" score in the latter is clearly due to the slow, deliberate method of work. Subject 72 also scores "high" in the criterion and low in time. Her scores are almost identical with those of subject 66. She is a mature woman who worked very slowly and deliberately.

(c) Checker Puzzle. There is a "present but low" positive correlation between the scores in the Checker Puzzle and the criterion. The correlation is partly explained by elements found also in each of the other tests. This test as far as the criterion is concerned is most like Rational Learning (Modified and least like the Tait Labyrinth Puzzle. The correlation is not significant when the common elements found also in the other tests are removed.

The correlation-ratios for the criterion and the Checker Puzzle are .49 and .54. These values substituted in Blakeman's formula give 2.71 and 3.05, indicating that both of the regression lines are non-linear. Table XXV shows the two regression lines. If they were smoothed they would be nearly straight and show very little correlation. In other words the high correlation-ratio is to a great extent due to the fluctuation of the means of the rows and the means of the columns.

Table XXV. Showing the Distribution of Subjects on the Basis of the Checker Puzzle and the Binet-Simon Tests. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



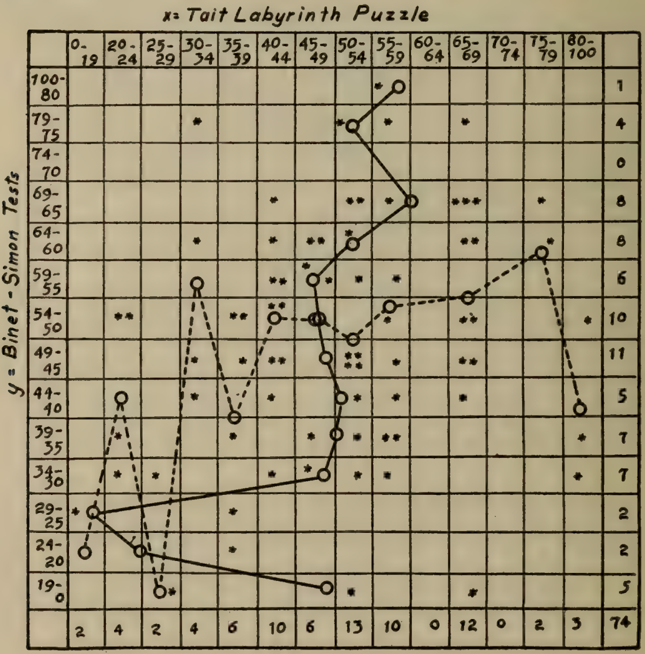
Analysis of the individual cases shows no mental functions tested by the Checker Puzzle that are not also tested by the criterion. This may be due to the fact that the responses of the subjects cannot be recorded so exactly as in the other tests. Partial correlations of the third order show that this test contains nothing with respect to the criterion that is not contained in the two Rational Learning Tests.

(d) Tait Labyrinth Puzzle. The correlation between the criterion and the Tait Labyrinth Puzzle is positive and "present but low." The correlation is partly due to elements found also in Rational Learning, and to a less extent to elements found in Rational Learning (Modified) and the Checker Puzzle. The correlation is barely significant when the elements common to all three tests are removed.

The individual cases reveal no mental functions tested by the Tait Labyrinth Puzzle that are not tested by the criterion.

The correlation-ratios for the criterion and the Tait Labyrinth Puzzle are .46 and .54. These values substituted in the Blakeman formula give 2.22 and 2.86, indicating that one regression

TABLE XXVI. Showing the Distribution of Subjects on the Basis of the Tait Labyrinth Puzzle and the Binet-Simon Test. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows.



line is linear and the other non-linear. The line joining the means of the rows is linear and the other is non-linear. Table XXVI shows the two regression lines.

(2) Interrelation of Tests Scored in the Light of the Criterion.

The four tests are here compared with each other as they are scored in the light of the criterion.

TABLE XXVII. Showing the Correlations and Partial Correlations of the Four Tests, When Scored in the Light of the Criterion.*

23	.36	24	.32	25	.41
23·4	.29	24·3	.23	25·3	.38
23·5	.32	24·5	.24	25·4	.36
23·45	.27	24·35	.17	25·34	.35
34	.32	35	.18	45	.26
34·2	.23	35·2	.04	45·2	.15
34·5	.28	35·4	.11	45·3	.22
34·25	.22	35·24	.01	45·23	.14

* The numbers have the same meanings as in Table XXIII.

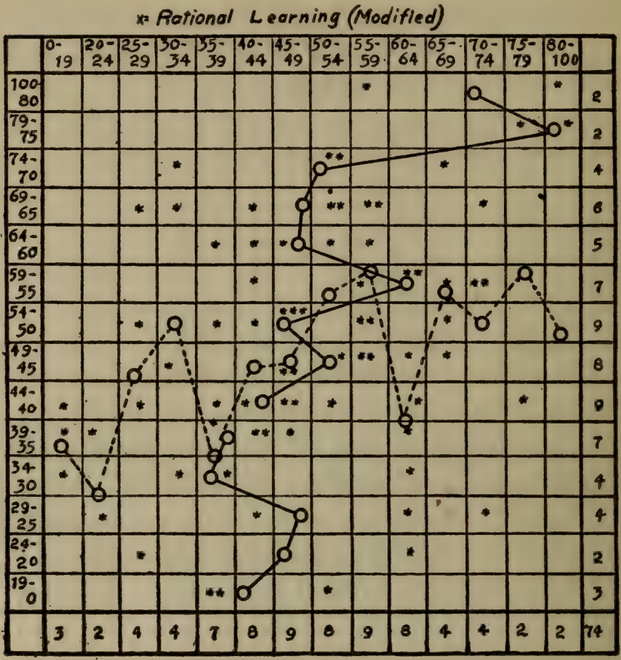
Rational Learning has a "present but low" positive correlation with Rational Learning (Modified) and with the Checker Puzzle. It has a "marked" correlation with the Tait Labyrinth Puzzle. There are elements common to Rational Learning and Rational Learning (Modified) that are not found in the Checker Puzzle and the Tait Labyrinth Puzzle. In like manner there are elements common to Rational Learning and the Tait Labyrinth Puzzle that are not found in the other two tests. The correlation of Rational Learning with the other three tests combined is .53.

The correlation of Rational Learning (Modified) and the Checker Puzzle is "present but low." The correlation with the Tait Labyrinth Puzzle is barely significant. There are elements common to Rational Learning (Modified) and the Checker Puzzle not found in the other two tests. The correlation of this test with the other three combined is .48.

The Checker Puzzle has a "present but low" positive correlation with the Tait Labyrinth Puzzle. The correlation is mostly due to elements found also in Rational Learning and Rational Learning (Modified). The correlation with the other three tests combined is .41.

The Tait Labyrinth Puzzle has a correlation with the other

TABLE XXVIII. Showing the Distribution of Subjects on the Basis of Rational Learning and Rational Learning (Modified). Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



three tests combined of .43. The multiple correlations may be summarized as follows:

$$R_{2(345)} = .53$$
$$R_{3(245)} = .48$$
$$R_{4(235)} = .41$$
$$R_{5(234)} = .43$$

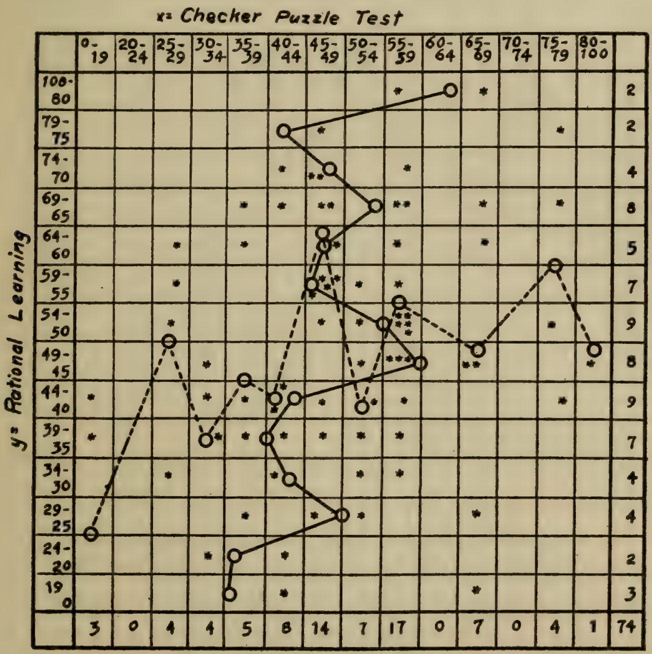
After allowance is made for errors and non-linearity, it seems safe to conclude that each of these tests contains elements that are not found in any of the others. The correlation-ratios for the inter-relations are as follows:

23 = .51 and .57
24 = .46 and .60
25 = .47 and .51
34 = .51 and .58
35 = .35 and .51
45 = .43 and .46

When these values are substituted in the Blakeman formula, results obtained are as follows:

Tests 2 and 3, 2.30 and 2.82
Tests 2 and 4, 2.02 and 3.23
Tests 2 and 5, 1.46 and 1.93
Tests 3 and 4, 2.01 and 3.08
Tests 3 and 5, 1.91 and 3.04
Tests 4 and 5, 2.18 and 2.42

Table XXIX. Showing the Distribution of Subjects on the Basis of Rational Learning and the Checker Puzzle. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



Four of the six correlations are non-linear according to the Blakeman test. The correlation of tests 2 and 5 and of tests 4 and 5 may be considered linear. Tables showing the lines of the means of the columns and the means of the rows will now be constructed for the non-linear correlations.

Table XXVIII shows the correspondence between the scores in Rational Learning and Rational Learning (Modified). The lines appear linear from the thirteenth to the sixteenth percentiles and show a high correlation within these limits. Outside of these limits, however, the fluctuations are marked and consequently the correlation-ratio becomes larger than the correlation.

Table XXIX shows the correspondence between the scores in Rational Learning and Checker Puzzle. These regression lines when smoothed will be approximately straight and will show a

TABLE XXX. Showing the Distribution of Subjects on the Basis of Rational Learning (Modified) and the Checker Puzzle. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.

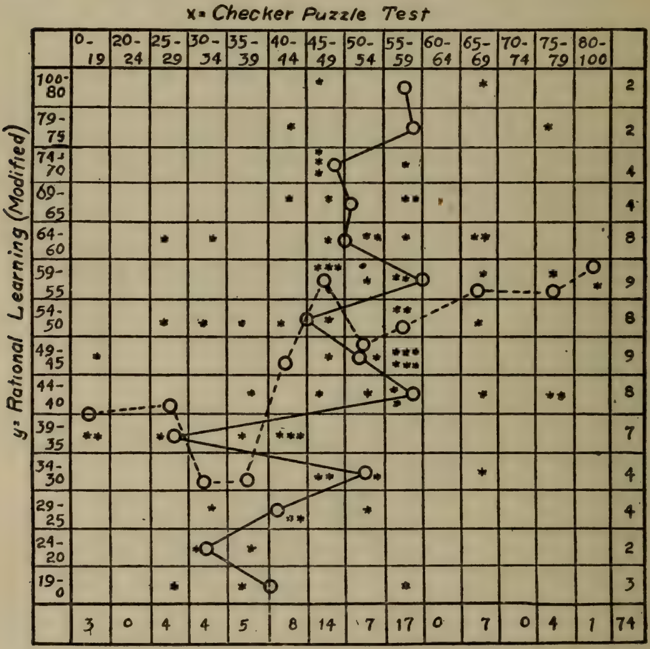
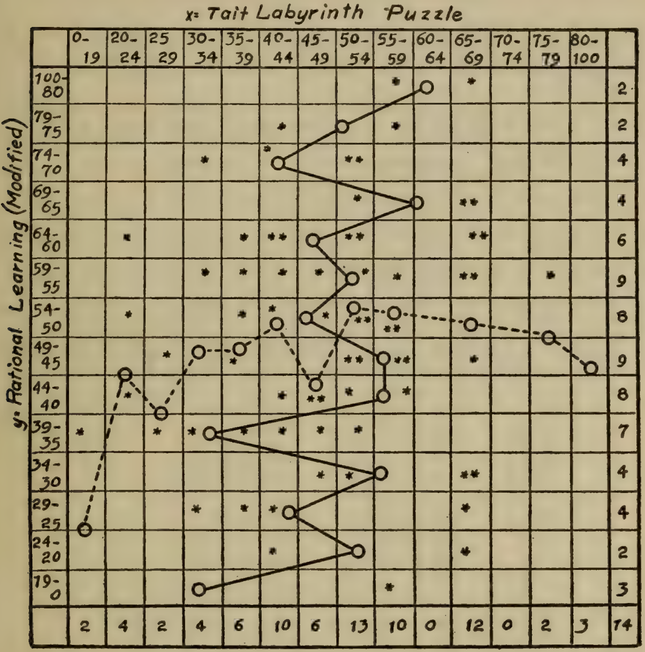


TABLE XXXI. Showing the Distribution of Subjects on the Basis of Rational Learning (Modified) and the Tait Labyrinth Puzzle. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



low positive correlation. An increase in ability to do the Checker Puzzle shows an increase in ability to do Rational Learning. The reverse, however, is not so true. An increase in ability to perform Rational Learning does not show very much change in ability to perform the Checker Puzzle.

Table XXX shows the correspondence between the scores in Rational Learning (Modified) and the Checker Puzzle. The line of the means of the rows smoothed will be approximately straight, but the other regression line will be far from straight. There seems to be closer agreement between the two sets of scores in the upper quartiles than in the lower.

Table XXXI shows the agreement of scores in Rational Learning (Modified) and the Tait Labyrinth Puzzle. An increase in ability in Rational Learning (Modified) is accompanied by an increase in ability in the Tait Labyrinth Puzzle. Here again, the reverse is not true. After the fiftieth percentile, an increase in ability in the Tait Labyrinth Puzzle is accompanied by a decrease in ability in Rational Learning (Modified).

(3) Interrelation of Tests Scored by Combining the Factors Equally.

The next step will be to analyze the four tests when scored by combining all the factors equally. The final scores in Rational Learning are obtained by adding together the percentile ranks in time, repetitions, unclassified, logical and perseverative errors and then reducing to absolute percentiles by use of Rugg's table. The final scores in the other tests are found in a similar manner.

Table XXXII. Showing the Correlations and Partial Correlations, When Scored by Combining All the Factors Equally.*

23	.33	24	.18	25	.44
23·4	.29	24·3	.06	25·3	.37
23·5	.21	24·5	.08	25·4	.41
23·45	.20	24·35	.01	25·34	.37
34	.38	35	.33	45	.26
34·2	.34	35·2	.21	45·2	.20
34·5	.32	35·4	.26	45·3	.15
34·25	.31	35·24	.15	45·23	.14

* The numbers have the same meaning as in Table XXIII.

Rational Learning has something in common with each of the other tests. It is most like the Tait Labyrinth Puzzle and least like the Checker Puzzle. The correlation with the former is "marked" and with the latter is barely significant. Everything in the Checker Puzzle common to Rational Learning is also found in the Tait Labyrinth Puzzle, and in Rational Learning (Modified). There are elements common to Rational Learning and Rational Learning (Modified) that are not found in the Checker Puzzle and the Tait Labyrinth Puzzle. In like manner there are elements common to Rational Learning and the Tait Labyrinth Puzzle that are not found in the other two tests. The correlation of Rational Learning with the other three tests is .48.

Rational Learning (Modified) has a "present but low" positive correlation with the Checker Puzzle and with the Tait Labyrinth Puzzle. The correlation with the other three tests combined is .48. This means that there is much in this test common to the other three tests and much that is not found in them.

The Checker Puzzle test has a low correlation with the Tait Labyrinth Puzzle. It correlates with the other three tests combined to the extent of .40. The Tait Labyrinth Puzzle has a correlation with the three remaining tests of .49. The multiple correlations may be summarized as follows:

$$R_2(_{345}) = .48$$
$$R_3(_{245}) = .48$$
$$R_4(_{235}) = .40$$
$$R_5(_{234}) = .49$$

We may safely conclude that each of these tests contains much that is not found in any of the other tests. The correlation-ratios are as follows:

23 = .45 and .49
24 = .33 and .54
25 = .50 and .61
34 = .53 and .59
35 = .47 and .49
45 = .40 and .47

When these values are substituted in Blakeman's formula, the following results are obtained:

For tests 2 and 3, 1.95 and 2.30
For tests 2 and 4, 1.76 and 3.24
For tests 2 and 5, 1.51 and 2.61
For tests 3 and 4, 2.35 and 2.88
For tests 3 and 5, 2.13 and 2.30
For tests 4 and 5, 1.96 and 2.49

According to the Blakeman test three of the correlations are linear and three are non-linear. The correlation of Rational Learning with Rational Learning (Modified) is linear, but with the Checker Puzzle and the Tait Labyrinth Puzzle it is non-linear. The correlation of Rational Learning (Modified) with the Checker Puzzle is non-linear, but with the Tait Labyrinth

Puzzle it is linear. The correlation of the Checker Puzzle with the Tait Labyrinth Puzzle is linear.

Table XXXIII shows the correspondence between scores in Rational Learning and the Checker Puzzle. The line joining the means of the rows shows that as ability in Rational Learning increases there is not much change in ability in the Checker Puzzle until the seventieth percentile is reached and then the increase is rapid. A smoothed curve through the means of the columns will show that as ability in the Checker Puzzle increases the ability in Rational Learning slowly increases until the fifty-fifth percentile is reached and then there is a decrease in ability up to the seventy-fifth percentile.

TABLE XXXIII. Showing Distribution of Subjects on the Basis of Rational Learning and the Checker Puzzle. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.

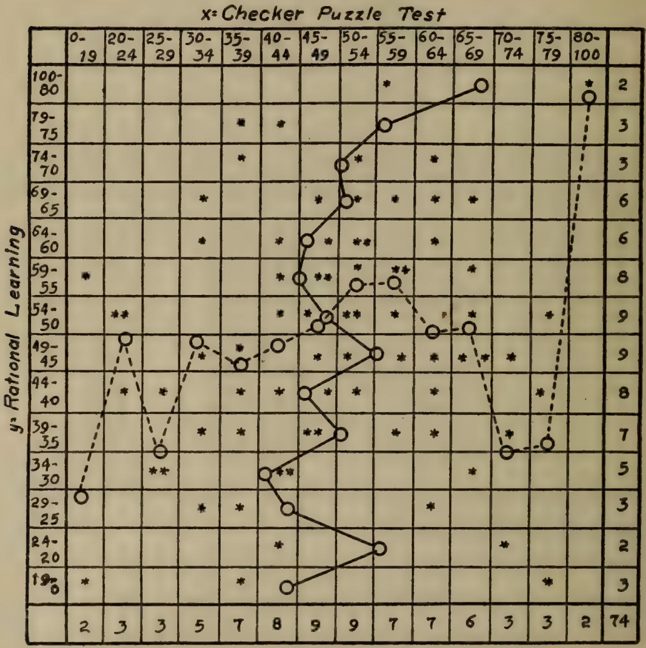
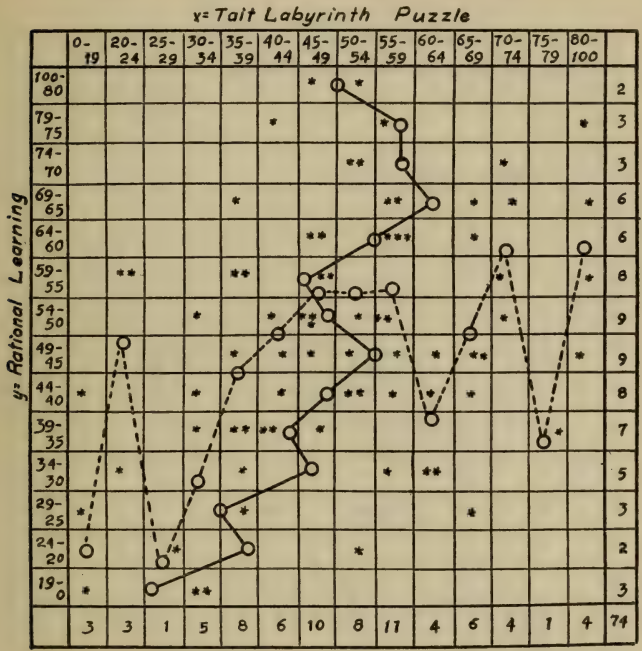


Table XXXIV shows that the agreement between the scores in Rational Learning and the Tait Labyrinth Puzzle is not very

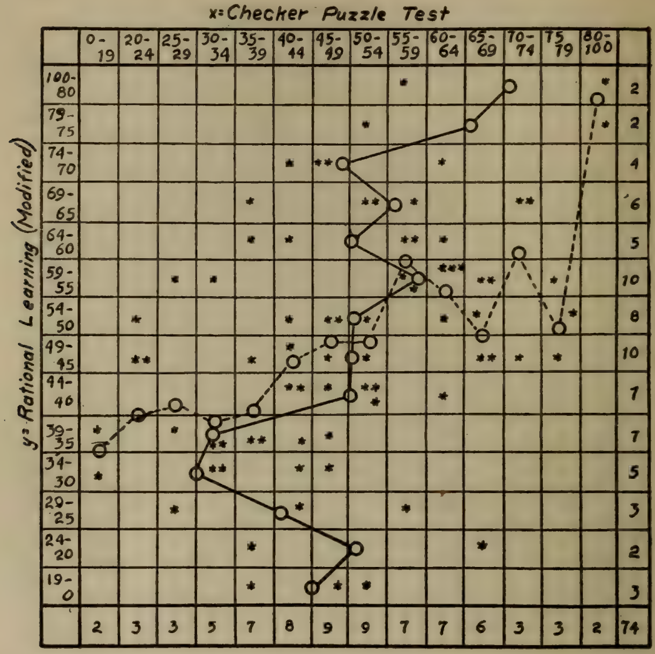
TABLE XXXIV. Showing the Distribution of Subjects on the Basis of Rational Learning and the Tait Labyrinth Puzzle. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



close. A smoothed curve through the means of the rows indicates that as ability in Rational Learning increases, there is a slight increase in ability to solve the Tait Labyrinth Puzzle up to the sixty-fifth percentile and then a slight decrease in ability from this point on. The line joining the means of the columns is very irregular. Beginning with the twenty-fifth percentile, as ability to solve the Tait Labyrinth Puzzle increases, there is a rapid increase in ability in Rational Learning. From this point on, there is little relation between the two sets of abilities.

Table XXXV shows the agreement between the scores in Rational Learning (Modified) and the Checker Puzzle. The line joining the means of the columns is linear according to the Blakeman test. It shows that as ability to solve the Checker Puzzle increases, there is also a constant but slow increase in

Table XXXV. Showing the Distribution of Subjects on the Basis of Rational Learning (Modified) and the Checker Puzzle. Circles through which the broken line passes represent the means of the columns and those through which the continuous line passes represent the means of the rows. Each asterisk represents a subject.



ability in Rational Learning (Modified). The line joining the means of the rows is non-linear. From the twentieth to the thirtieth percentiles, ability in the Checker Puzzle decreases with an increase in ability in Rational Learning (Modified). From the thirtieth percentile on, there is a slight increase in ability to solve the Checker Puzzle as the ability in Rational Learning (Modified) increases.

X. A Discussion of Learning and Intelligence

Learning of the reflective or problem solving kind has often been looked upon as involving, among other factors, one general mental function or process. It has been assumed that the person who has good reasoning ability in one problem will be good in all others of this same general type. This conception implies that there is always a high correlation between any two such problems. In this investigation, however, the correlations are not high. In fact, they are all comparatively low. The lowest is .18 and the highest .44. The conclusion is that there is not one general rational learning process, but a number of processes. Two tests as similar as Rational Learning and Rational Learning (Modified), although they have something in common, are to a large degree independent of each other, since they have a correlation of only .36. This conception that any two tests have something in common and something that is not common has been explained in two ways. The first is the Two Factor theory of intelligence set forth by Spearman. The second assumes that each activity, such as a mental test or learning problem, involves a specific number of factors combined in a specific way. These two theories will now be treated in order.

Spearman set forth his Two Factor theory of intelligence in 1904. His first statement of the theory was as follows: "All branches of intellectual activity have in common one fundamental function (or group of functions), whereas the remaining or specific elements of the activity seem in every case to be wholly different from that in all the others."[33] This statement should be supplemented by the following explanation:

"It was never asserted, then, that the general factor prevails exclusively in the case of performances too alike: it was only said that when this likeness is diminished (or when the resembling performances are pooled together), a point is soon reached where the correlations are still of a considerable magnitude, but now indicate no common factor except the General one. The latter, it was urged, produces the basal correlation, while the similarities merely superpose something more or less adventitious."[34]

His most recent statement of the theory is:

"The purport of this theory is that the cognitive performances of any person depend upon: (a) A general factor entering more or less into them all; and (b) a specific factor not entering appreciably into any two, so long as these have a certain quite moderate degree of unlikeness to one another."[35]

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[33] Spearman, C., General Intelligence, Objectively Determined and Measured, *Amer. J. Psychol.*, 1904, *15*, 201 ff.

[34] Hart, B., and Spearman, C., General Ability, Its Existence and Nature, *Brit. J. of Psychol*, 1912, *5*, 51 ff.

Spearman's method was to measure a number of mental abilities in a number of persons and then calculate the correlation coefficients of each of these abilities with each of the others. He then noticed that these correlation coefficients had a certain relationship among themselves, which he called a hierarchial order. By this he means that if the coefficients of correlation of a number of mental functions are arranged in a descending order from left to right and from top to bottom as is usualy done in a correlation table, in every row the figures will be in a descending order as they are in the top row, and in every column the figures will be in a descending order as they are in the left column. This also means that in any table of correlations as ordinarily arranged, every column will have a perfect correlation with every other one. Spearman has also reduced this principle to the following exact mathematical equation:

$$r_{ap}/r_{aq} = r_{bp}/r_{bq},$$

in which a, b, p and q indicate any of the tests and r is the correlation between them.

It seems evident that the presence of such a general factor will always produce this hierarchy. In fact, if it can be shown that all correlations arrange themselves in such an order, it might be difficult to formulate any other theory to account for the facts. One exception, however, is enough to disprove the theory, since, if there is such a general factor, all correlations must take this hierarchical form. Thompson[36] has shown that it is possible with dice throws to get a set of correlation coefficients in excellent hierarchical order. He says that these imitation mental tests contain no general factor. Spearman, on the other hand, claims that Thompson let in a general factor at the back door. It seems to the writer that Thompson has proved nothing more than that it is possible occasionally to get the hierarchial order of correlation coefficients when there is no general factor present. He has not weakened Spearman's argument in the least, provided Spearman can always get this order. Thompson further claims in this same article that the hierarchical order is the natural relationship among correlation coefficients. The writer is unable to see, however, just how his argument bears upon the question. He is willing, of course, to admit that this inability may be due to his lack of insight.

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[35] Spearman, C., Manifold Sub-Theories of the "The Two Factors," *Psychol. Rev.*, 1920, *27*, 159 ff.

[36] Thompson, Godfrey H., General versus Group Factors in Mental Activities, *Psychol. Rev.*, 1920, *27*, 173 ff.

Spearman, in order to prove his theory, must show that every group of correlation coefficients of intellectual functions has, within the limits of experimental accuracy, this hierarchical order. Then his theory will hold only until it has been shown that this same order can be obtained consistently when there is no common factor present. The data of this investigation and their bearing upon the question are here presented.

Table XXXVI. Showing the Correlation Coefficients, when the Tests are Scored in the Light of the Criterion

	1	3	2	5	4
1		47	33	30	26
3	47		36	18	32
2	33	36		41	32
5	30	18	41		26
4	26	32	32	26	

In no column, except the first where it was deliberately arranged, does the hierarchy exist. Spearman would probably say that the mental functions here tested are too much alike for the criterion to hold. The correlations are so low, however, that this claim can hardly have weight. Our findings are indeed adverse to the Two Factor theory. If we examine the correlations and partial correlations in Table XXVII, it will be evident that no factor of any size whatever is common to all the mental functions tested. For instance the correlation of tests 2 and 5 is .41. When the elements in test 3, common to 2 and 5, are removed, the correlation is still .38. This indicates that there is almost nothing common to the three tests. This same conclusion can be deduced from other cases in this same table. The correlation of tests 2 and 3 with the common elements in 5 removed, of tests 3 and 4 with the common elements in 5 removed, of tests 4 and 5 with the common elements in 3 removed, leads to the conclusion that there is no common factor large enough to account for all the correlations. Table XXXII shows the same conditions. The correlation of tests 2 and 3 with the common elements in 4 removed, of tests 2 and 5 with the common elements in 4 removed, of tests 3 and 4 with the common elements in 2 removed, shows that there are no elements common to all the tests sufficient to account for all the correlations.

Our data indicate that there is no common factor of any size running through all the tests. This amounts to saying that there is no such thing as general intelligence. What then is the nature of intelligence? One other theory will be considered. This theory assumes that in carrying out any activity, such as a mental test, a number of factors are at play. Each activity involves a specific number of factors combined in a specific way. The specific factors combined will differ with different individuals and with the same individual at different times. It will sometimes happen that a number of elements will run through several mental activities. In this case there may be said to be an element common to all the activities. In other cases there will be no element or elements common to more than two or three of the mental functions. For instance, tests 1 and 2 may correlate because of element a, tests 1 and 3 because of element b, tests 2 and 3 because of element c, etc.

This theory seems to be in harmony with the data of this investigation. According to the Two Factor theory, the correlations in Table XXXIII show that test 3, Rational Learning (Modified), must have more of the general factor than any other test; yet when the elements in this test common to the criterion and test 2, to the criterion and test 4, or to the criterion and test 5, are removed, the correlation is still nearly three times the probable error. If test 3 contains more of the general factor than any other test and all correlation is due to this factor, then it should be reduced nearly to zero when the common elements in this factor are removed. On the other hand, the theory of various elements variously combined can easily account for all correlations and partial correlations. That is, tests 1 and 2 have common elements, some of which are found in each of the other three tests and some of which are not found in any of the other three tests. The same conclusion may be drawn from tests 1 and 3 and tests 1 and 5. Probably everything common to tests 1 and 4 is found in tests 2 and 3 or tests 3 and 5.

If we now turn to Table XXVII, it is evident from the viewpoint of the Two Factor theory that test 5 or test 2 has more of the general factor than any of the other tests; yet when the elements in 5 common to 3 and 4 are removed, the correlation is .28. This is an impossible result if the Two Factor theory is true. Table XXXII will also show similar conditions. Test 2 or test 5 must have enough of the general factor to make the correlation of these two tests .44. The other test may have more of this factor, but cannot have less if Spearman's theory is true. Now since the amount of the general factor involved in either of the two remaining tests, must be less than that involved in test 2 or test 5, the correlation of these tests, 3 and 4, should be reduced to zero, when the common elements in 2 or 5 are removed. Yet the correlation remains .31 when the common elements in both are removed.

These data, which cannot be explained at all by the Two Factor theory, are easily explained by the theory that intelligence consists of a large number of factors variously grouped and combined. Suppose that the correlation of tests 2 and 3 in table XXXII is due to elements a, b, c, d, e, f, g, h, i, and j. Now suppose that element a is the only one of these ten that is found in test 4, and that elements b, c, d, and e are the only ones of the ten found in test 5. When the element a is removed from the ten common ones, the correlation is reduced from .33 to .29. In like manner, when the elements b, c, d, and e are removed, the correlation is reduced from .33 to .21. When the elements a, b, c, d, and e are removed, the correlation is reduced from .33 to .20. Thus, we have ten elements common to tests 2 and 3, one element common to tests 2, 3, and 4, four elements common to tests 2, 3, and 5. This analysis is not literally correct. There is undoubtedly a common factor of very small importance running through all four tests. This is evident from the fact that $r_{23 \cdot 45}$ is not much less than $r_{23 \cdot 4}$ or $r_{23 \cdot 5}$. That is, most of the elements in test 4 common to tests 2 and 3 are contained in the elements in test 5 common to tests 2 and 3. An examination of any of the correlations and the accompanying partial correlations will show that a very small factor runs through all four tests. This factor, however, is not sufficient to account for the correlations.

It seems that most of the investigations, when interpreted by Spearman, are in harmony with the Two Factor theory, but when interpreted by others, are adverse to this theory and more in harmony with the other theory here discussed. Thorndike[37] has recently made a study, using the Army Tests and a large number of subjects. His data are not in harmony with the Two Factor theory. He says in this article:

"We have considered the correlations obtained from time to time in various studies at Teachers College from the point of view of the Spearman theory, and have in general not been able to corroborate it. The most extensive data at our disposal (McCall, '16) seemed decidedly adverse."

Thorndike in this same article further says:

"We must, it appears, turn back with open mind to the details on intercorrelations and experimental analysis to work out the organization of intellect. Especially needed seem studies of the 'partial' inter-correlations with one after another of the factors equalized."

[37] Thorndike, Edward L., On the Organization of Intellect, *Psychol. Rev.*, 1921, *28*, 141 ff.

Simpson[38] discussed general intelligence and the bearings of his study upon the Two Factor theory. He says:

"We find justification for the common assumption that there is close inter-relation among certain mental abilities, and consequently a something that may be called 'general mental ability' or 'general intelligence'; and that on the other hand certain capacities are relatively specialized, and do not imply other abilities except to a very limited extent."

He says again: "We find no justification for the view that 'general intelligence' is to be explained on the basis of a hierarchy of mental functions, the amount of correlation in each case being due to the degree of connection with a common central factor."

Peterson[39] makes the following statement as to the nature of general intelligence: "General intelligence, if it is a reality at all, is probably not a separate constant factor, but a composite of many different abilities, and probably means different things in unlike situations, as different abilities are stressed. Such factors as energy and perseverance, degree of disturbance by emotions and self-consciousness, and many others that play their role in one's success in life, have not yet been successfully brought into the field of measurement by tests, especially by group tests."

XI. SUMMARY AND CONCLUSIONS

A. Method. The essential features of the method used in this investigation are:

(1) Four tests of the problem solving or rational learning type are used. Two of these tests have five kinds of data—time, repetitions, and three kinds of errors. One has three kinds of data—time, attempts and solutions. One has two kinds of data—time and number of trials. A criterion, the Stanford Revision of the Binet-Simon tests, is used in finding the best method of scor-

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[38] Simpson, Benj. R., Correlations of Mental Abilities, *Teachers' College Contributions to Education,* 1912 (No. 53).

[39] Peterson, Joseph, Intelligence and Its Measurement, *J. of Educ. Psychol.,* 1921, *12,* 198 ff.

ing or combining the different kinds of data and in analyzing the tests.

(2) The raw scores in the criterion and in each factor of each test, and the final scores are transmuted into percentiles. This has been found very helpful in calculating correlations. For instance, all standard deviations as well as all the means are made approximately equal. The analysis of the curves through the means of the rows and columns is also simpler when the standard deviations are equal.

(3) Every factor in a test is correlated with the criterion and with every other factor. Then a complete set of partial correlations is worked out. This makes it possible to determine which factors must be used in scoring in order not to discard any elements in common with the criterion. For instance, it was found in Rational Learning that repetitions and perseverative errors contain everything in all the factors in common with the criterion. That is, everything in the other three factors is a duplication of these common elements in repetitions and perseverative errors.

(4) To determine the best combination of the factors that need to be retained, formula (2) is used. Formula (3) is then used to determine what this correlation is. As a check on the work, formula (1) is used. This gives the highest possible correlation of all the factors with the criterion. If this result agrees closely with that obtained from formula (2), it is evidence that the analysis and work are correct. It so happened that not more than two factors needed to be combined in any of the tests; but if it had been necessary to combine three or more factors, two would have been combined in the best way and then this result with the third factor. The writer has combined as many as five factors in this way and found it very satisfactory.

(5) For every correlation, Blakeman's criterion for linearity is applied. If non-linearity exists according to this criterion, the actual curves of the means of the rows and columns are constructed. The writer regards the correlation-ratio and the Blake-

man criterion of very little value unless the number of cases is large enough to eliminate most of the fluctuations in the curves through the means of the rows and columns. These fluctuations are often sufficient to produce a high correlation-ratio when there is no correlation, and, of course, non-linearity is indicated when the criterion is applied. The actual curves through the means of the rows and columns are of more significance, since it is possible to determine the general direction of such curves in making analyses.

(6) The final scores of each test are analyzed by comparing them with the criterion through the use of partial correlations and multiple correlation. It does not seem possible to do much with partial correlations in analysis unless a criterion is used.

(7) The final scores as obtained in the light of the criterion are correlated with each other and partial correlations worked out. In comparing the tests with each other, the multiple correlation method is found very valuable. Especially is this the case in determining how much each test has in common with all the others.

(8) As a final step in the technique, the tests are scored by combining all the factors in a test equally. This was thought best, since there was a possibility of accentuating certain elements in the tests by scoring them in the light of the criterion.

B. Results. The results indicated by the data are as follows:

(1) In scoring Rational Learning in the light of the criterion, repetitions and perseverative errors are the significant factors. Time, unclassified errors, and logical errors only duplicate the elements in these two factors. Time and unclassified errors are the significant factors in Rational Learning (Modified); the other three factors may be discarded. The number of solutions is the significant factor in the Checker Puzzle. Time and number of attempts add nothing. In the Tait Labyrinth Puzzle the number of trials is the significant factor. Time is unessential. It might be interesting to note here that in three of the four tests, time is an unessential factor. This does not mean, however, that the same results would have been obtained if the subject

had been told that time was not being considered. The correlations would probably have been very different. Time is probably not important in the Checker Puzzle and the Tait Labyrinth Puzzle. In Rational Learning the subject is controlled somewhat by the experimenter but in Rational Learning (Modified) he is free to go as fast as he wishes. This probably accounts for the difference in the value of the time factor in the two tests. In Rational Learning (Modified) the space perception makes it easier to avoid perseverative errors, and for that reason this factor becomes unessential. It is thought best to make no comparison of the difficulty of the two rational learning tests, since each subject had already taken Rational Learning (Modified), when he took Rational Learning. The similarity was usually recognized at once. It was not uncommon to have the subject say while he was reading the directions for Rational Learning, "This is just like that bell-ringing thing."

(2) Rational Learning and Rational Learning (Modified) seem to test or measure mental functions 'not detected by the intelligence tests. These may be summarized as follows: first, the ability to attack and solve a problem without getting confused; second, the ability to give attention longer than that usually required in mental tests; third, the type of attack made by the subject; and fourth, the speed of the subject. The objective data do not reveal any mental functions tested by the Checker Puzzle and the Tait Labyrinth Puzzle over and above those tested by the criterion.

(3) Rational Learning (Modified) correlates considerably higher with the criterion than does any of the other tests. This may be partly due to the fact that this test was given first. The Checker Puzzle has the lowest correlation with the criterion. Rational Learning (Modified) has elements in common with the criterion that are not found in the other three tests. The same is probably true of the Tait Labyrinth Puzle, but to a less extent. Rational Learning and the Checker Puzzle have nothing in common with the criterion that is not found in the other tests.

(4) When the tests are scored in the light of the criterion,

every correlation indicates something in common between the two tests correlated. The correlations of the second order also indicate that each pair of tests, except 3 and 5, have something in common that is not contained in the other tests. The factor running through all four tests is almost zero. Multiple correlation shows that each test has much that is not contained in the other three tests. The Checker Puzzle has most, the Tait Labyrinth comes second and Rational Learning has least. The differences are so small that they are probably not significant.

(5) When the tests are scored by combining all the factors in a test equally, the same general results are obtained as in the other method of scoring. There are some differences, however, in specific correlations. These are evident when tables XXVI and XXXII are examined. The correlations of test 2 with test 3 and test 5 are not changed much, but the correlation of test 2 with test 4 is reduced about half. The correlation of test 3 with test 4 is not changed much, but that of test 3 with test 5 is about doubled. The relations of test 4 with test 5 remain exactly the same. The multiple correlations show very little change in general by the two methods of scoring.

(6) There is nothing in the data of this investigation to justify the Two Factor theory of intelligence. In fact, everything is adverse to this theory. If the testing and the calculations are absolutely free from errors, the results obtained are impossible on the basis of the Two Factor theory. The correlations and partial correlations can be accounted for, however, by the theory that intelligence consists of various factors variously grouped for different situations.

BIBLIOGRAPHY

1. Freeman, F. N., *Experimental Education,* 1916.
2. Hart, B., and Spearman, C., General Ability, Its Existence and Nature, *Brit. J. of Psychol.,* 1912, *5,* 51ff.
3. Lindley, E. H., Study of Puzzles, *Amer. J. of Psychol., 8,* 430ff.
4. McCall, W. A., Correlation of Some Psychological and Educational Measurements, *Teachers College Contributions to Education,* 1916, (No. 79).
5. Peterson, Joseph, Experiments in Rational Learning, *Psychol. Rev.,* 1918, *25,* 433ff.
6. Peterson, Joseph, The Rational Learning Test Applied to Eighty-one College Students, *J. of Educ. Psychol.,* 1920, *11,* 137ff.
7. Peterson, Joseph, Intelligence and Its Measurement, *J. of Educ.* Psychol., 1921, *12,* 198ff.
8. Rosenow, Curt, The Analysis of Mental Functions. *Psychol. Monog.,* 1917, *24,* (No. 106).
9. Rugg, H. O., *Statistical Methods Applied to Education,* 1917.
10. Ruml, Beardsley, The Reliability of Mental Tests in the Division of An Academic Group, *Psychol. Monog.,* 1917, *24,* (No. 105).
11. Simpson, Benj. R., Correlation of Mental Abilities, *Teachers College Contributions to Education,* 1912, (No. 53).
12. Spearman, C., General Intelligence, Objectively Determined and Measured, *Amer. J. of Psychol.,* 1904, *15,* 201ff.
13. Spearman, C., Manifold Sub-Theories of "The Two Factors," *Psychol. Rev.,* 1920, *27,* 159ff.
14. Strong, E. K. Jr., The Learning Process, *Psychol. Bull.,* 1918, *15,* 328ff.
15. Terman, Lewis M., *The Measurement of Intelligence,* 1916.
16. Thompson, Godfrey H., General versus Group Factors in Mental Activities, *Psychol. Rev.,* 1920, *27,* 173ff.

17. Thorndike, Edward L., Combining Incomplete Judgments of Relative Position, *J. Phil. Psychol. and Sc. Methods,* 1916, *13,* 197ff.
18. Thorndike, Edward L., On the Organization of Intellect, *Psychol. Rev.,* 1921, *28,* 141ff.
19. Thurstone, L. L., A Scoring Method for Mental Tests, *Psychol. Bull.,* 1919, *16,* 235ff.
20. Yule, G. U., *Introduction to The Theory of Statistics.*

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